Biodiversity Analysis of Selected Riparian Ecosystems within a Fragmented Landscape

Prepared by:
Reuben R. Goforth, Ph.D., David Stagliano, Yu Man Lee,
Joshua Cohen, Michael Penskar

Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

For:
Michigan Great Lakes Protection Fund
and
Michigan Department of Environmental Quality, Office of the Great Lakes

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Michigan DNR

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

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ABSTRACT

Riparian ecosystems of the Great Lakes Basin influence the quality of the Great Lakes and provide habitat for many characteristic elements of biodiversity within the region. Extensive human landscape modifications have dramatically changed the character of terrestrial and aquatic ecosystems in Michigan, especially in Lower Michigan, where riparian ecosystems are among the only remaining contiguously forested areas within highly fragmented landscapes. The significance of these isolated riparian ecosystems for maintaining regional biodiversity in a highly fragmented landscape is not fully understood. Historically, these areas have been poorly inventoried, and only a few elements of biodiversity are locally well known. This study was initiated to gain a better understanding of the biodiversity refuge potential of riparian corridors within fragmented landscapes. Our approach was unique in that we surveyed multiple elements of both terrestrial and aquatic communities, including plants, natural communities, breeding birds, amphibians and reptiles, and multiple aquatic taxa. We used multivariate statistics to determine whether these community parameters were patterned among riparian corridors with varied levels of riparian forest width and connectivity. Overall, the results of this study provided some support for the idea that biodiversity refuge potential of riparian corridors within fragmented landscapes can be predicted based solely on corridor width and contiguity, primairly with respect to terrestrial flora and some vertebrate groups. However, aquatic community parameters were much more responsive to varied channel types than to riparian corridor widths. Spatial analysis of land cover properties of local and upstream riparian buffer areas provided an additional level of correlation analysis for riparian community components and multi-scale environmental properties of landscapes. These multi-spatial analyses identified some strong associations between community measures and upstream properties, suggesting that riparian biodiversity modeling and management may need to be conducted at larger spatial scales in order to be effective. While the overall results of this study did not wholly support the sole use of riparian corridor width and contiguity as guiding factors for identifying riparian biodiversity potential in fragmented landscapes of southern Lower Michigan, further study that includes appropriate criteria for determining the integrity of streams with varied channel characteristics may lead to more definitive models of riparian biodiversity that do provide greater evidence for the use of riparian corridors as broad scale models for prioritizing conservation targets within landscapes.

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INTRODUCTION

Riparian areas serve as functional interfaces within landscapes, mediating matter and energy exchange between terrestrial and aquatic ecosystems (Hynes 1970, Meehan et al. 1977, Peterjohn and Correll 1984, Gregory et al. 1987, Gregory et al. 1991). Riparian forests and associated floodplains are transitional zones, or ecotones, between terrestrial and aquatic ecosystems. Ecotones are considered areas of particularly high diversity because they encompass sharp environmental gradients and diverse ecological processes (Ricklefs 1989). Like other ecotones (e.g., wetland/upland interface), riparian zones tend to be rich in biodiversity. The limited spatial extent of riparian ecosystems within landscapes belies their biodiversity value in terms of both the variety and abundance of local taxa and diversity of available microhabitats (Kaufman and Krueger 1984, Nilsson et al. 1988, Medin and Clary 1990, Gregory et al. 1991, Naiman et al. 1993). As such, the potential for remnant riparian corridors in fragmented landscapes to act as biodiversity refugia should be considered high.

Riparian corridors may harbor twice the number of species occurring in adjacent upland areas (Gregory et al. 1991). This trend towards higher species richness in riparian areas can be multiplied quickly as anthropogenic disturbance of upland areas intensifies. Fluvial processes such as erosion, flooding, channel migration and sediment deposition are widely regarded to influence the distribution and occurrence of individual plant species and plant communities within riparian ecosystems (Gregory et al. 1991, Mitsch and Gosselink 1993, Baker and Walford 1995). Intact riparian corridors often support higher diversity bird, reptile, amphibian and small mammal communities by providing necessary hibernacula, breeding sites and foraging areas (Carothers et al. 1974, Carothers and Johnson 1975, Kauffman and Krueger 1984, Doyle 1990, Olson and Knopf 1988, Burbrink et al. 1998). In adjacent streams, riparian forest canopy provides shade that limits instream primary productivity and water temperature fluctuation (Sweeney 1993). Leaf-fall materials from riparian forest canopies provide the primary energy base for invertebrate food webs, particularly in headwater streams (Hynes 1975, Gregory et al. 1987, Gregory et al. 1991, Sweeney 1993). Woody riparian zones also physically limit the movement of soils and nutrients from land surfaces to stream channels (Peterjohn and Correll 1984, Lowrance et al. 1984, Behmer and Hawkins 1986, Gregory et al. 1987, Osborne and Kovacic 1993, Reed and Carpenter 2002). Clearly, riparian forests play important roles in structuring associated terrestrial and aquatic communities, although studies of community level responses to multi-scale changes in riparian and landscape land cover properties are just beginning to emerge (e.g., Allan et al. 1997, Goforth 1999).

Human-induced landscape changes may be the greatest contributing factor for the decline of ecological resources. Habitat destruction is one of the five largest threats to aquatic ecosystem health and biodiversity (Karr and Chu 1999). The primary human disturbance to watersheds of eastern North America has been deforestation. This is demonstrated by the small percentage of old-growth native forests remaining. Secondary growth forests are the norm for eastern North America, and native forests within the southern Lower Peninsula of Michigan are no exception (Albert 1994). A secondary response to forest removal has been the use of newly cleared landscapes for cattle grazing and row-cropping. In the last 200 years, cultivation, livestock grazing and other anthropogenic activities have destroyed 80% of the riparian corridors along North American and European streams and other water bodies (Dechamps and Naiman 1989, Dix et al. 1997). Southern Lower Michigan's landscape is no exception and has been modified for agricultural land uses, fragmenting the forests that remain. Habitat fragmentation and resulting edge effects can significantly reduce native biodiversity (Wilcox and Murphy 1985). However, habitat corridors, such as riparian/floodplain ecosystems, may potentially sustain viable populations of native plants and animals (Saunders and de Rebeira 1991, Harris and Scheck 1991, Bratton et al. 1994). Riparian ecosystems therefore represent potential habitat for sustaining a significant portion of regional biodiversity within southern Michigan's fragmented landscapes.

In this study, the extent to which remnant riparian forests in fragmented northern landscapes provide refuge for native biodiversity was evaluated by surveying plant, selected terrestrial vertebrate, fish and aquatic invertebrate communities within riparian corridors of varied width and connectivity. These streams were also characterized by varied channel morphology, ranging from shallow, faster flowing stream reaches with coarse substrates to much more deeply incised channels with fine substrates and slower flow. The central hypothesis of this study was that native plant, terrestrial vertebrate and aquatic community attributes of riparian ecosystems within fragmented landscapes are dependent upon the width and connectivity of the riparian corridors in which they exist. We predicted that species richness, the relative abundance of intolerant and native taxa, and measures of terrestrial and aquatic community integrity associated with riparian ecosystems of agricultural landscapes would be higher in wider, more contiguous riparian forest corridors with shallow, faster flowing streams. Stream community integrity measures based on fish, benthic macroinvertebrate and mussel communities were expected to be positively correlated with higher quality habitat properties (except the Mussel Biotic Tolerance Index, which was expected to be negatively associated with higher quality habitat properties). These higher quality aquatic habitats were also expected to be associated with increasing forest buffer width. We expected that ecological descriptors of plant communities would vary according to multiple factors, including riparian width and connectivity, and within-site ecological zones. We also expected that our community and ecological response variables would be variably associated with land cover properties of varying buffer widths adjacent to and upstream from our sample sites.

METHODS

Study Areas

Riparian sites surveyed during 2000 and 2001were chosen based on forested buffers estimated from USGS topographic maps (1:24,000 scale) and aerial photos (Michigan Department of Natural Resources 1988, 1999). Twenty-seven total riparian areas were sampled, including 12 study areas in 2000 (Figure 1) and 15 study areas in 2001 (Figure 2). Riparian areas selected for this study represented three different forested riparian buffer classes (<125m, 125-250m and 250-500m) and three different channel types (Table 1). The channel types included shallow (A), moderately incised (B) and deeply incised (C). The suite of sample basins was chosen based on their locations within central southern Lower Michigan. Sites were identified by river basin, riparian buffer class and channel type (e.g., GR<125A is the <125m, shallow channel site in the Grand River basin). Selected study sites ranged from small 3rd order to large 4th order stream reaches. Access to selected riparian areas was based on landowner permission; this immediately narrowed the potential number of sites considerably. Secondary criteria involved accessibility of the river for transporting sampling equipment. Selected access points were evaluated to determine whether aquatic and terrestrial habitats representative of the entire study area were present. A 150-m stream reach served as a sampling unit for the aquatic surveys and variably sized adjacent riparian areas (up to one linear km) were designated as sampling sites for terrestrial vertebrate, vegetation and floristic sampling.

Aquatic Community Surveys

Habitat quality evaluation is critical for assessing ecological integrity given that biological diversity and stream habitat integrity have been shown to be closely linked (Raven 1998). Instream habitat and surrounding topographic features are major determinates of aquatic community potential (Plafkin et al. 1989, Barbour and Stribling 1991). Physical habitat characterization was evaluated using the US Environmental Protection Agency's (EPA) Habitat Assessment Field Data Sheet for Low Gradient Streams (Barbour et al. 1999), hereafter referred to as the HQI. This visual-based assessment method guides users to examine 10 site physical parameters using a rating scale from 1-20 for a best possible reach score of 200. The HQI reflects professional-based judgements of stream condition (i.e., meander, riffle/run/pool ratios, habitat availability, riparian disturbance, etc.) in relation to ideal conditions that could be expected for a sites in pristine condition. The HQI was performed in conjunction with stream morphology measurements of stream width, channel depth, substrate characterization and % woody substrate taken at 10-m increments within the reach. Instream woody substrate is reported as the percentage of wood surface area per length of stream bottom in a transect (e.g., 4 m of wood in a 16-m wide transect=25% woody cover). Since the HQI integrates habitat metrics that range from instream substrate to the immediate riparian area, it is a good measure of the overall reach habitat condition that can be measured consistently among sites.

Fish communities were sampled at each of the 27 study reaches from June through September in 2000 and 2001 using a Coffelt™ gas-powered backpack electroshocker and a 6.5-m, ¼" mesh, straight-haul seine. Depletion survey methods were not used for abundance data. Instead, a qualitative species depletion method (Saylor and Alhstedt 1992) was used to obtain a representative species occurrence list and species relative abundance measures. Beginning at the bottom of the reach and working in an upstream direction, a single electroshocking pass was made that included all habitats within 3-5 m from the streambank. In wide riffle areas, the seine was deployed and held in place in the current while an area 5 m upstream from the net was fished using the shocker, effectively driving fish into the seine. This method significantly reduces fish injuries and mortality commonly resulting from kickseining. Netted and electroshocked fish were placed in a bucket and held in fresh stream water until they were identified and released.

Deep runs and pools were sampled by mad-dog seining, during which surveyors pulled a seine in a downstream direction rapidly enough to maintain an

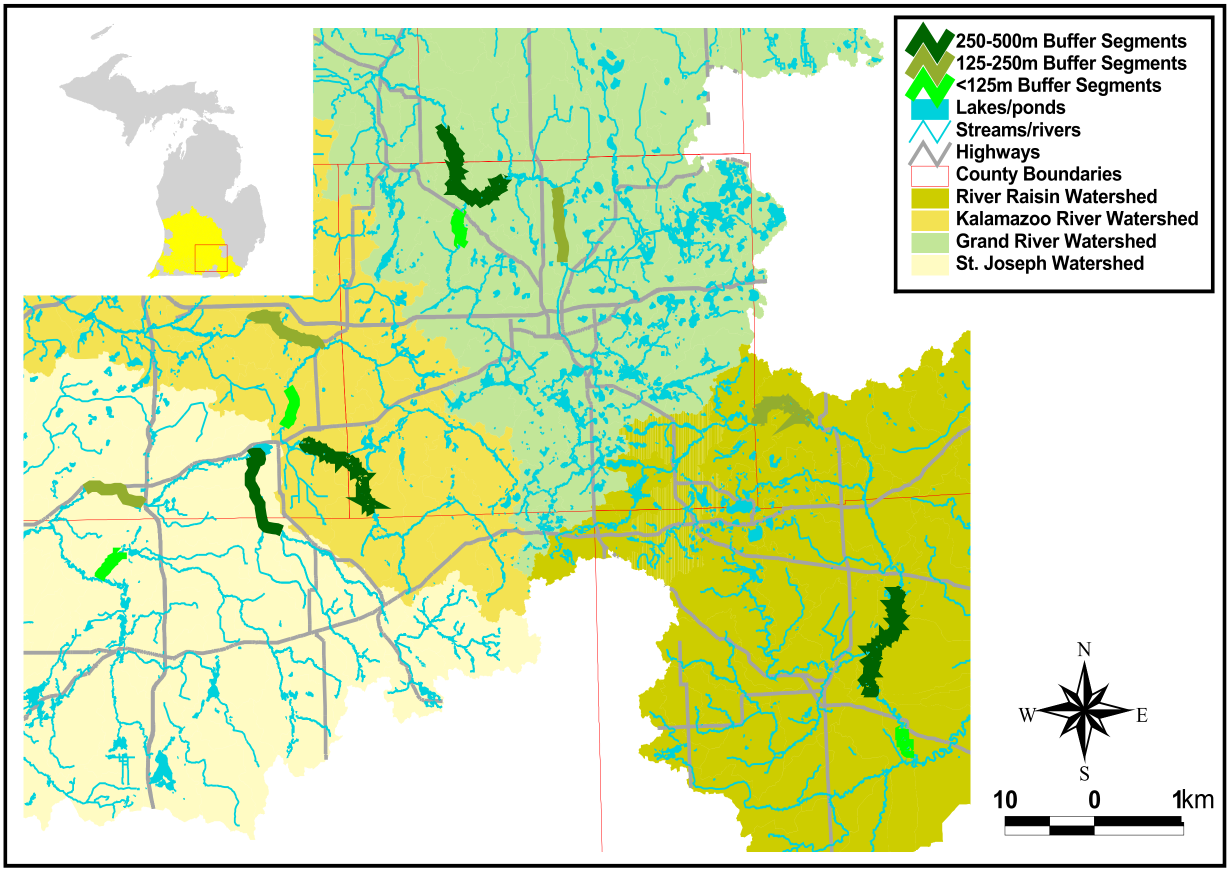

Figure 1. Twelve riparian study areas visited in the Grand, Kalamazoo, Saint Joseph and Raisin River watersheds during Summer 2000.

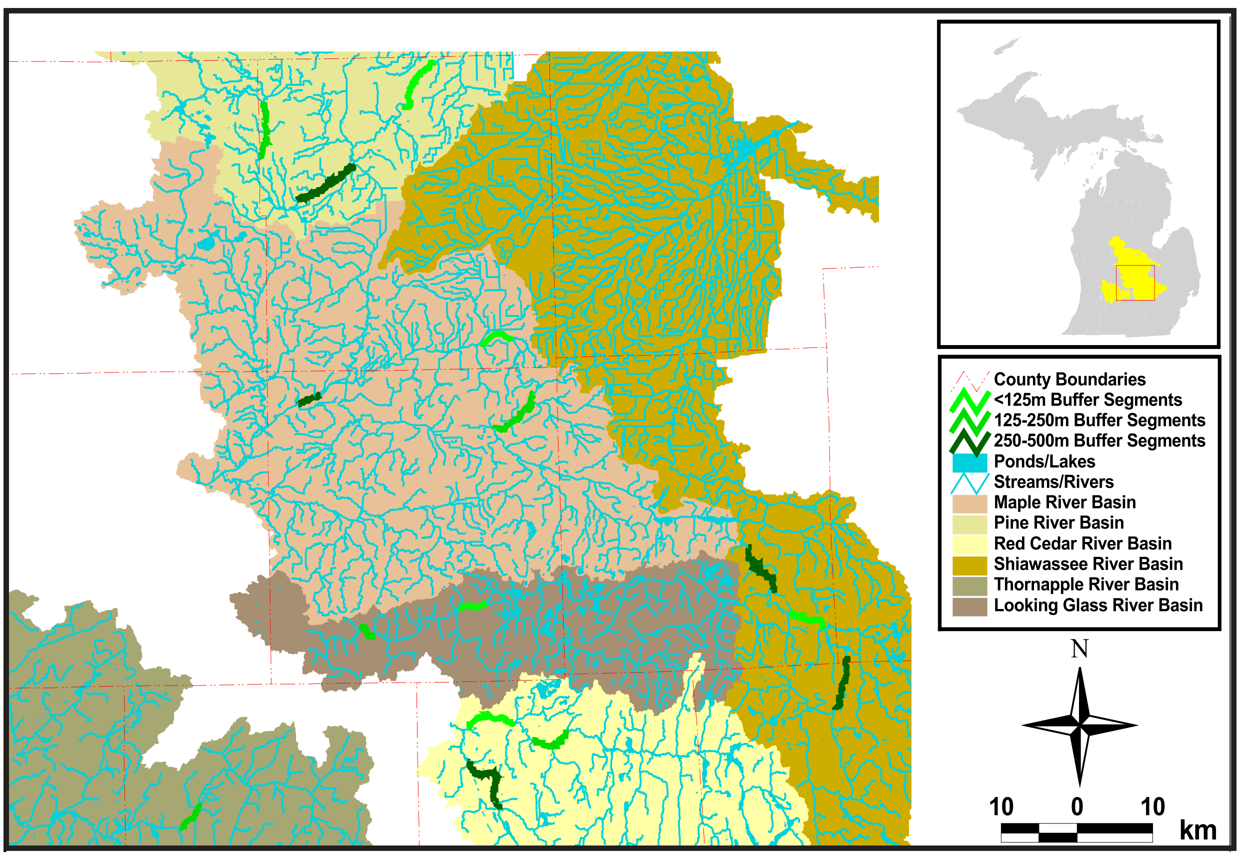

Figure 2. Fifteen riparian study areas visited in the Pine, Looking Glass, Red Cedar, Shiawassee, Thornapple and Maple Rivers during Summer 2001.

Table 1. Riparian class and channel type designations for riparian study areas sampled in 2000 and 2001. Channel types include shallow (A), moderately incised (B) and deeply incised (C).

River (Code)	Riparian Width Class	Channel Type
Grand River (GR)	<125m	A
	125-250m	C
	250-500m	C
Kalamazoo River (KZ)	<125m	A
	125-250m	A
	250-500m	A
Maple River (MR)	<125m	C
	125-250m	B
	250-500m	C
Pine River (PR)	<125m	A
	125-250m	B
	250-500m	B
River Raisin (RR)	<125m	C
	125-250m	A
	250-500m	A
Shiawassee River (SH)	<125m	B
	125-250m	A
	250-500m	C
Saint Joseph River (SJ)	<125m	B
	125-250m	B
	250-500m	B
Looking Glass River (LG)	<125m	C
	125-250m	A
Red Cedar River (RC)	<125m	B
	125-250m	C
Sycamore Creek (SC)	250-500m	B
Thornapple River (TR)	125-250m	C

upstream bow in the seine and lead–line contact with the bottom. At the end of the seine run (≈20 m) fish were encircled in a slow-current area or beached. Fish seined using these methods were recorded separately from the eletroshocking efforts. Fish were identified to species (Page and Burr 1991), counted, examined for overall condition and age, and then released. Mortality rates were very low using these methods, although the few specimens lost to mortality were retained as vouchers.

Modified Indices of Biotic Integrity (Karr 1981, using Midwest modifications after Barbour et al. 1999) were used to estimate the fish community integrity (FIBI) of each site (poor to high scores ranging from 12-60). The site electroshock effort was reported in seconds, but was converted to minutes when reporting catch per unit effort (FCPUE). Tolerance and trophic values required for the IBI were determined from Barbour et al. (1999). In addition to the FIBI, the relative abundance of intolerant individuals in the total catch (RAIF) was used as an additional measure of stream quality, given the assumption that intolerant species will become scarce with increasing levels of disturbance.

Mussels were sampled using a catch-per-unit-effort approach because the emphasis of our study was to determine species composition and relative abundance and not to quantify densities. Catch-per-unit-effort techniques provide a more comprehensive picture of site mussel assemblages than substrate excavation quadrat methods and are more likely to locate rare mussels (Strayer et. al 1996, Vaughn et al. 1997). Visual surveys were conducted along a series of defined transects (nine per site) across the width of the stream. Aquascopes (glass bottomed buckets) were used for underwater viewing while wading, or in depths >1 m, SCUBA was utilized along transects. Mussels (and dead valves) observed during the timed-transect period were placed in mesh bags for later processing. Live individuals collected were identified to species, enumerated and released in the field. Dead valves were taken back as a collection record to be deposited at the University of Michigan museum, but were not included in the survey data.

This survey technique enabled surveyors to search an entire cross-section of the stream without bias towards the best habitat. Surveyors on each side of the stream channel worked toward the middle, searching approximately one meter above and below the transect line. This procedure began at the most downstream transect in the reach. Pools and runs were sampled within each site, including a range of substrate types (e.g., silt, sand, gravel and rock). Visual surveys tend to be biased toward larger individuals, but by remaining consistent across all stream reaches, the data collected were expected to be comparable across sites. Time searched by the surveyors was converted to catch per unit effort (MCPUE) expressed as #mussels/person-hour. Tolerant and intolerant mussel species were reported as the relative abundance of tolerant and intolerant individuals in the total catch (RATU and RAIU, respectively). In addition, a Mussel Biotic Tolerance Index (MBTI) was also calculated to reflect the overall tolerance of mussel communities at sites to environmental degradation.

Benthic invertebrate samples were collected from riffle habitats using a 500-µm mesh Surber™ sampler. Nine Surber samples were taken within each reach during the summer months of 2000 and 2001. At each site, sampling was initiated at the most downstream riffle, and subsequent samples were collected by systematically moving upstream with each sampling effort. Three replicate samples were collected from each riffle within the study area. If shallow riffle areas were not present, but suitable substrate was present, an alternative quantitative method was used. A long-handled dip net (12”x 24” net opening, 500-µm mesh) was held firmly against the stream bottom and the substrate 0.5 m upstream from the net was thoroughly disturbed to dislodge benthos. EPA's multi-habitat dipnet sampling protocol (Barbour et al. 1999) was used to collect aquatic invertebrates from all substrates and microhabitats within each reach (i.e., deep riffles, undercut backs, logjams and macrophytes). A multi-habitat sample was taken at the lower and upper reach of the site (n=2, ~75 m represented for each discrete sample). To collect the samples, 20 0.5-m jabs were taken in proportion to the habitat types identified in the reach using a 500-µm mesh dip net. Contents of the net were washed thoroughly and preserved using 70% ethanol (EtOH). Samples were later processed and identified (genus/species level) in the laboratory using protocols and taxonomic resources outlined in Barbour et al. (1999).

Total aquatic invertebrate species richness (BNSR) and the total number of Ephemeroptera, Plecoptera and Trichoptera taxa (i.e., EPT Index) reported for each site were estimated by combining species collected using both sampling methods. The benthic invertebrate biotic index (INBI) and the relative abundance of intolerant benthic invertebrates (RAIB) were calculated by averaging data from six Surber samples (multi-habitat sample data were not used in these calculations). These calculations involve the use of tolerance values of the organisms (ranked 0-10, Barbour et al. 1999), or their ability to withstand degraded environmental conditions. Invertebrates intolerant of disturbance are represented by low ranks (0-3), while those very tolerant of disturbance are ranked higher (7-10). The INBI was calculated by multiplying the number of individuals of taxon $_{(i)}$ found in a sample (n^I) by that taxon's tolerance value (TV^i) and summing all ($n^i TV^i$) in the sample. Finally, this sum is divided by the total number of individuals in the sample (TN) to derive the INBI for the sample. Six INBI values were averaged to provide a mean INBI value for each site. The RAIB was simply the sum of all individuals with tolerance rankings 0-2 divided by the total number of individuals in a sample.

Vegetation and Floristic Surveys

Vegetation and ecological sampling for the 27 riparian study sites was conducted from 22-May to 15-Jun 2000, 17-Aug to 29-Aug 2000, 7-Jun to 28-Jun 2001 and 20-Aug to 28-Aug 2001. These sampling periods were selected to optimize identification of both early and late season floras, given that it was not possible to conduct more than two visits per riparian study area. The locus of vegetation sampling within survey sites was established following a thorough site reconnaissance and timed meander search. This approach facilitated the identification of a representative sampling transect within the study area (see below). During the preliminary site assessment, the number of distinct ecological zones (e.g., levee, first bottom, second bottom, sparsely forested bottom, upland forest, etc.) was determined. Transects were established approximately perpendicular to stream reaches in areas that captured the variability of microhabitats observed and that facilitated sampling across a site's ecologically distinct zones.

Plastic piping was staked at the origin of the base transects, marking the immediate river edge. Measuring tapes (m) were drawn out to the edge of the riparian buffer, and a transect compass bearing was taken and recorded. The width of each distinct ecological zone was measured and a random number table was used to determine the location of sampling transects within each zone. These transects were oriented perpendicular to the initial base transect. Five flags were placed along each of the sampling transects within the different zones. The location of these flags was also determined using a random number table. These numbers defined the number of paces to be used along the sampling transect. For each zone, flags were placed on each side of the base transect with either three on the right side and two on the left side or two on the right side and three on the left. The flags were used as the center of three sampling plots: a $1m^2$ groundcover plot, a 5m radius circular understory plot and a 10-factor prism plot for the overstory.

Within each ecological zone, a nested sampling scheme was used to establish 15 sampling plots. A $1m^2$ sampling frame was used for the groundcover plots. Within each groundcover plot, species were identified and assigned a percent cover value. The mean number of species per plot (GCS) and mean percent groundcover per plot (%GC) were calculated for each site. In areas that were seasonally inundated, the water depth within 1 m^2 plots was measured. Within the 5 -m radius plots, all woody stems and vines less than four inches in diameter and greater than one meter high were identified and tallied. The mean number of understory species (USSp) and mean number of understory stems per plot (USSt) were calculated for each site. Within the 10-factor prism plots, trees greater than four inches in diameter were identified and tallied. Trees within adjacent prism plots were alternately included only in the first or last plot sampled to avoid repeated tallying of the same trees. Diameter at breast height (DBH) was noted for each tree within the prism plot. The mean total basal area (m^2/hectare, BA) per plot, the mean number of tree species per plot (NTS) and mean DBH per plot were calculated for each site. Data from the 10-factor prism plots were used to generate the mean BA by site and zone. Site means were derived by weighting zone means according to the amount of area sampled within a given zone.

The base transect was also used to establish a topographic profile for each site. Starting from the riverbank, a clinometer was used to determine the elevation above or below the starting point five and 10 m away. This was accomplished by positioning a leveled piece of plastic pipe (marked at three inch increments along its length) at the five and 10 m intervals along a transect. A clinometer was sighted from the transect zero point to determine the elevation at each point surveyed relative to the zero point. This procedure was repeated at intervals of 10 m over the entire transect. A topographic profile was graphed for each site and a coefficient of topographic variation (CTV) was calculated to provide a measure of elevational variability within and between sites. The CTV was calculated by dividing the standard error of the height above or below the riverbank by the mean height above or below the riverbank.

In addition to the quantitative surveys, each site was qualitatively evaluated. Notes were taken describing anthropogenic disturbance; flood status and extent; structural diversity; microhabitat variability; abundance and status of dead and down material; and the extent and pervasiveness of exotic, adventive or dominant species. Representative sites and zones were photographed when possible or as appropriate. Field forms were completed for rare plant species as well as for floodplain communities recognized as high quality examples of southern floodplain forest. Following field sampling, rare plant and natural community occurrences were transcribed and processed into MNFI's statewide BioTICS database.

All communities surveyed during this study were defined in relation to the Michigan Natural Features Inventory (MNFI) Natural Community Classification (MNFI 1990). Two community types were identified during this study, southern floodplain forest (occurring at every site) and prairie fen (occurring in only one floodplain buffer). Assessment of natural community quality was guided by established MNFI methodology detailed in MNFI (1988). In addition, the quality of surveyed communities was gauged by consulting the MNFI statewide BioTICs database, which contains benchmark examples of southern floodplain forests and prairie fen. Those surveyed communities determined to meet the qualifying criteria were included as high quality occurrences in the statewide database and appropriately ranked.

A complete floristic list was compiled for the 27 riparian sampling sites by identifying all vascular plants within each study area. An initial list was compiled by first conducting a timed meander search of a site encompassing all observed habitats and microhabitats. This included surveying the vegetation of the river and river edge, levee areas, successive flood bottoms (e.g., first bottom, second bottom, etc.), mounds and other notable rises, seasonally inundated areas and backwaters, depressions, and upland areas up to the extent of the *a priori* delimited forested buffer zone. Following the meander search, which also served as general site reconnaissance for selecting a subsequent representative sampling transect, new species were added as they were observed within and adjacent to vegetation sampling plots.

An existing field checklist for southern floodplain forest based on the MNFI natural community classification (MNFI 1990) was used to compile an initial species list, and additional species were added as they were encountered and identified. All floristic surveys took place in conjunction with vegetation and ecological sampling during the periods noted previously. Specimens of species that could not be reliably identified in the field were collected for verification and keying. Collections included large numbers of sedges (especially *Carex* spp.), rushes and grasses. Sterile specimens were also collected for further study to attempt to identify them beyond genus level. A relatively small number of specimens were pressed and dried so that they could be verified by botanical experts and/or submitted as appropriate to the University of Michigan Herbarium (MICH); these included voucher specimens for the documentation of new occurrences of rare species and a few significant county records. Taxonomy and nomenclature for flowering plants largely follows the Michigan Flora (Voss 1996, 1985, 1972), with the exception of Case (1987) for orchids, Case and Case (1997) for trilliums, and Gleason and Cronquist (1991) for a more contemporary treatment of the genus *Carex* and other sedges. Lastly, pteridophytes (ferns and fern allies) follow the North America Flora treatment provided in Morin et al. (1993), as this group is not included in the Michigan Flora.

Following all field sampling and specimen verification, species lists for each site were compiled. A careful review was conducted by examining field checklists with the vegetation sampling data for each site as well as specimen identification lists; these were further reconciled with a master species list compiled for all sampling sites. Following a full reconciliation of these data, plant lists for each site were entered via a Floristic Quality Assessment (FQA) program (Wilhelm and Masters 2000) containing an embedded Michigan flora list. Herman et al. (1996) and Swink and

Wilhelm (1994) provide a detailed description of this system and its applications. Floristic Quality Assessment (FQA) was designed as a tool to assess the floristic integrity of sites (i.e., ecological integrity or natural area quality) based upon the objective application of a subjectively determined value for each native plant species known as its “coefficient of conservatism” (Herman et al. 1996, Swink and Wilhelm 1994). The Coefficient of conservatism (*C*), which follows a 0-10 scale, can be defined as the estimated probability that a plant occurs within a plant community relatively unaltered from what is believed to be a presettlement condition. Low values are given to plants with little fidelity to remnant natural communities (e.g., *Acer negundo*, box elder), whereas high values are assigned to species that are consistently restricted to higher quality natural areas emulating presettlement conditions (e.g., *Potentilla fruticosa*, shrubby cinquefoil). A floristic quality index (FQI) is calculated by multiplying the mean coefficient of conservatism ($\overline{C}$) of a plant inventory by the square root of the total number of plants ($\sqrt{n}$): FQI = $\overline{C} \times \sqrt{n}$. The square root of *n* is used as a multiplier to enable a better comparison of FQI values between large sites with a high number of species and small sites with fewer species (Herman et al. 1996). In addition to the Chicago region (Swink and Wilhelm 1994) and Michigan, floristic quality assessment systems have also been prepared and used in Illinois (Taft et al. 1997), Ontario (Oldham et al. 1995), northern Ohio (Andreas and Lichvar 1995), and Missouri (Ladd, in prep.).

Our sampling sites were systematically assessed and compared with respect to several attributes as summarized by the FQA, including total floristic diversity, proportions of native and non-native species, FQI score, native mean coefficient of conservatism ($\overline{C}$) and average wetness coefficient. The FQA also provided a means by which to assess and summarize sites with regard to their respective proportions of physiognomic groups or life form categories (i.e., tree, shrub, vine, forb, grass, sedge or pteridophyte).

Terrestrial Vertebrate Surveys

Terrestrial vertebrate sampling in 2001 focused on two animal groups, breeding anurans (frogs and toads) and breeding birds, to acquire better analytical data. Focusing on fewer animal groups allowed for increased sample size, multiple survey visits to each site, and better estimates of community composition and relative abundance. Herpetofaunal (amphibian and reptile) surveys focused on frogs and toads because this group comprised the greatest proportion of herptiles found during the first year of this study (2000). Breeding birds were targeted for this study because they spend more time in these riparian ecosystems and are generally more consistent on a daily basis than migratory birds. To obtain better data on avian community composition and abundance during the breeding season, the migratory bird portion of the study was eliminated. Small mammal surveys and herpetofaunal surveys using drift fences and pitfall and funnel traps were also not conducted in 2001. Terrestrial vertebrate surveys were conducted at all 15 study sites in 2001 and 3 of the sites surveyed in 2000 (SJ <125m, KZ250-500m and RR250-500m) for a total of 18 sampling sites for the terrestrial vertebrate portion of the study.

Breeding frogs and toads were surveyed by conducting evening frog call surveys from 10-April to 4-July 2001. Surveys were conducted during three different time periods in the spring and summer (i.e., mid-to late April, late May to mid-June and late June to early July) to cover the range of anuran breeding periods, thus maximizing the number of frog species detected at study sites. Each site was to be surveyed once during each time period or survey window for a total of three visits. However, half of the sites were surveyed only during two of the three survey periods due to unseasonably cool and rainy weather and, hence, unsuitable survey conditions during the second survey window in May 2001. Surveys were conducted by listening for frog calls after dark (i.e., from about 8 PM to 2 AM) along a one-km transect parallel to the river. This methodology is a modified version of audio strip transect sampling described by Zimmerman (1994). Sites were visited and reconnoitered during the day prior to the first frog call survey to locate and flag the survey transect. Due to limited landowner permission at seven study sites, frog call survey transects at these sites were less than one km, ranging from approximately 180 m to 810 m. Frogs heard on both sides of the river within the extent of the *a priori* delimited riparian buffer width (i.e., <125m, 125-250m, 250-500m) were included. Species, estimated numbers of individuals, call index values, location, time and weather conditions were recorded during surveys. Call indices were defined in the following manner: 1 = individuals can be counted, space between calls (i.e., 1-5 individuals); 2 = individual calls can be distinguished but some overlapping calls (6-12 individuals); and 3 = full chorus, calls are constant, continuous and overlapping, unable to count individuals (Michigan Frog and Toad Survey Protocol 2000).

A single time-constrained (two person-hours) visual encounter survey (Crump and Scott 1994) was also conducted at 15 of the 18 study sites from 21-May to 30-May 2001 to supplement the frog call surveys. Visual encounter surveys were not conducted at three sites (i.e., LG<125, MR250-500 and SH250-500) due to unsuitable weather and habitat conditions during the survey period (i.e., unseasonably cool and rainy weather and very high water levels due to flooding at one site). Visual encounter surveys were conducted by walking three to six transects ranging from 110 m to one km in length during the two person-hour survey period. Transects were initiated immediately adjacent and parallel to the river or study reach, and subsequent transects were placed 10 m apart and further inland. Surveys were conducted during daylight hours and under appropriate weather conditions. These surveys involved overturning cover (i.e., logs, boulders, etc.), inspecting retreats, and looking for basking and active individuals in the river and on land. All animals encountered within one meter of the transect path were recorded. The species, number of individuals, age class, location (i.e., approximate distance from the river and along the transect), activity, substrate and time of observation were noted. Weather conditions and start and end times of surveys also were recorded.

Overall species composition and richness for each site were compiled by combining the species recorded from frog call surveys and visual encounter surveys. Incidental species observed during herp or aquatic surveys also were recorded but were not included in the species richness estimates. Relative abundance per site was calculated separately for frog call surveys and visual encounter surveys. Relative abundance based on frog call surveys was expressed as the mean number of frogs heard per night, which was derived by summing the total number of individuals heard at a site and dividing this number by the total number of survey nights. Full choruses were counted as a minimum of 13 individuals. Due to unequal transect lengths at several sites, relative abundance based on frog call surveys also was expressed as the mean number of frogs heard per meter per night. This was calculated by dividing the number of frogs heard per night by the transect length and averaging the values for each survey night per site. Relative abundance based on visual encounter surveys was expressed as the number of individuals per person-hour of survey time, which was derived by dividing the total number of individuals observed by two person-hours of survey time. Relative abundance estimates did not include incidental herp observations. All relative abundance estimates should be considered minimum estimates of frog abundance at the study sites.

Bird surveys using the point count method were conducted using standard methodology as outlined by Ralph et al. (1993, 1995). Breeding bird counts were conducted between sunrise and 1200 hr from 7-June to 26-June 2001. A point count station consisted of a 50-m radius circle within which all birds seen or heard were tallied for 10 minutes during the surveys. Birds seen or heard outside the 50-m radius circle were noted as well. All counts were conducted when there was no precipitation and little or no wind. Each station was located at least 50 m from the edge of the river and no closer than 50 m to the boundary of the riparian forested habitat. To ensure each bird was counted only once, point count stations were established at least 200 m apart. Three point count stations were established at 14 of the 18 study sites. Due to limited landowner permission and size of the remaining four sites, only two point count stations were established at three sites, and only one station at one site. Thus, a total of 49 point count stations were surveyed. In addition, all point count stations were surveyed twice during the breeding season, with two to 10 days between subsequent visits.

Standard field forms for point counts were used to record the birds seen and heard at each point count station. Species richness was calculated by counting the total number of species observed at each study site. Relative bird abundance and relative abundance of dominant species per site were calculated by counting the total number of birds within all point counts at a site and dividing by the total number of point counts for that site.

Spatial Analysis

A land cover database was developed from aerial photograph interpretations of areas adjacent to and upstream from the study stream sections using Geographic Information Systems (GIS, ESRI 2000). Aerial photographs from flyovers conducted for the Michigan Department of Natural Resources in 1988 and 1999 were used to create updated land cover databases. The 1988 photos were the most current data sources available when interpretation work began (2000), although 1999 imagery became available over the course of the study and was used to create the land covers during 2001. The black-and-white photos used depicted landscape properties at approximately 1:24,000 scale. Land covers were distinguished using interpretation techniques provided in Avery and Berlin (1985) and represented land cover classifications commonly identified for landscape data sets. Polygons representing homogeneous land cover units interpreted from the photos were hand-drawn on mylar overlays. The mylar line work was digitized using a large format

Eagle scanner. The resulting scanned images were converted to ArcInfo grids that were vectorized using the ArcScan command within ArcINFO (ESRI 2000). The resulting coverages were carefully edited for quality control, and the land cover polygons were attributed.

Nearstream buffers served as the primary spatial units. Stream buffers were created in ArcView that represented 30-m, 60-m, 120-m, 240-m, 480-m and-960-m buffer areas around selected stream segments (e.g., the 30-m buffer class included 15-m lateral bands on both sides of the selected stream segments). The buffers were used as templates to extract the land cover types that fell within the stream buffers using clipping procedures. Buffer delineations were chosen based on the common recommendation of preserving 30-m riparian buffers around streams in environmental planning (Petersen and Petersen 1992, Rabeni and Smale 1995) and the widths of the riparian existing conditions treatments used in the study (i.e., <125m, 125-250m and 250-500m). Buffer areas and associated land cover properties were quantified over four spatial scales, hereafter referred to as landscape contexts. The local landscape context was comprised of buffer areas immediately adjacent to each survey stream segment (Figure 3a). Buffer areas adjacent to the reach or reaches immediately upstream (U/S-1, 8 stream-km), two reaches upstream (U/S-2, 16 stream-km) and three reaches upstream (U/S-3, 24 stream-km) from each study site defined landscape contexts of progressively increasing scale (e.g., Figure 3b-d). The U/S-2 landscape context included the buffer areas and land cover properties of both the first and second reaches upstream from a survey site. The U/S-3 landscape context included the first, second and third buffer areas combined. Environmental properties beyond the U/S-3 context may have also influenced local biological and ecological properties of survey sites, although analyses of these potential associations were beyond the scope of this study.

In cases where upstream reaches included tributary confluences, only buffers for tributaries of equal order and those not more than one order lower than the survey reach were included in the analysis. Streams more than one order smaller than main stem survey reaches were not expected to have a significant influence on the dynamics of these reaches.

The proportion of the each buffer area encompassed by distinct land cover types was quantified for all landscape contexts using the GIS. Land cover types were combined into land cover groups according to expected similarity of influence on stream ecosystems, including forest (forest, brush and plantations combined), wetlands (all wetland types combined) forest-wetlands (forest, brush, plantations and wetlands combined), agricultural (row crop and pastures combined), and all modified (row crop, pasture, construction, extraction, residential, municipal and clear-cuts combined). Other land cover types that represented minor contributions to the landscape were not included in these classifications (e.g., water bodies and inactive agricultural tracts).

Statistical Analysis

Two-way factorial ANOVA was used to determine whether aquatic, terrestrial vegetation and flora, and terrestrial vertebrate parameters differed among the three riparian buffer width classes (<125m, 125-250m and 250-500m) and the three channel types (A, B and C). The least significant difference (LSD) post-hoc pairwise multiple comparison test was applied to determine specific means that were significantly different when the two-way factorial ANOVA indicated a significant difference among riparian buffer widths and/or channel types. Separate one-way ANOVA's were conducted when the interaction between buffer width and channel type was significant. All statistical results reported from the ANOVA and LSD tests were considered significant at $\alpha=0.05$. Spearman rank correlation analysis was used to investigate associations among aquatic taxa groups (e.g., fish and unionids), among terrestrial vegetation measures, and between frog and bird data and riparian habitat composition, floristics and structure. These data were also correlated with the proportions of land cover properties quantified within longitudinal buffers over multiple spatial contexts. Correlations were considered significant at $\alpha=0.005$.

RESULTS

Overall Results

Nearly 900 plant and animal species were observed during surveys of 27 riparian areas in southern Lower Michigan during 2000 and 2001. Native species observed included 475 plants, 60 birds, 12 herptiles, 52 fish, 25 mussels, and approximately 200 benthic macroinvertebrate taxa. Non-native species observed included 69 plants, one fish and two mollusks. In addition, 101 element occurrences for rare and unique species and terrestrial communities were observed and added to the MNFI BCD, including two vertebrate, nine invertebrate, and 11 plant species, as well as two natural community types (Table 2).

Total species richness across all taxa sampled was not different among the riparian classes or channel types surveyed ($F=1.6$, $p>0.20$ and $F=1.5$, $p>0.25$, respectively), although there was a non-significant

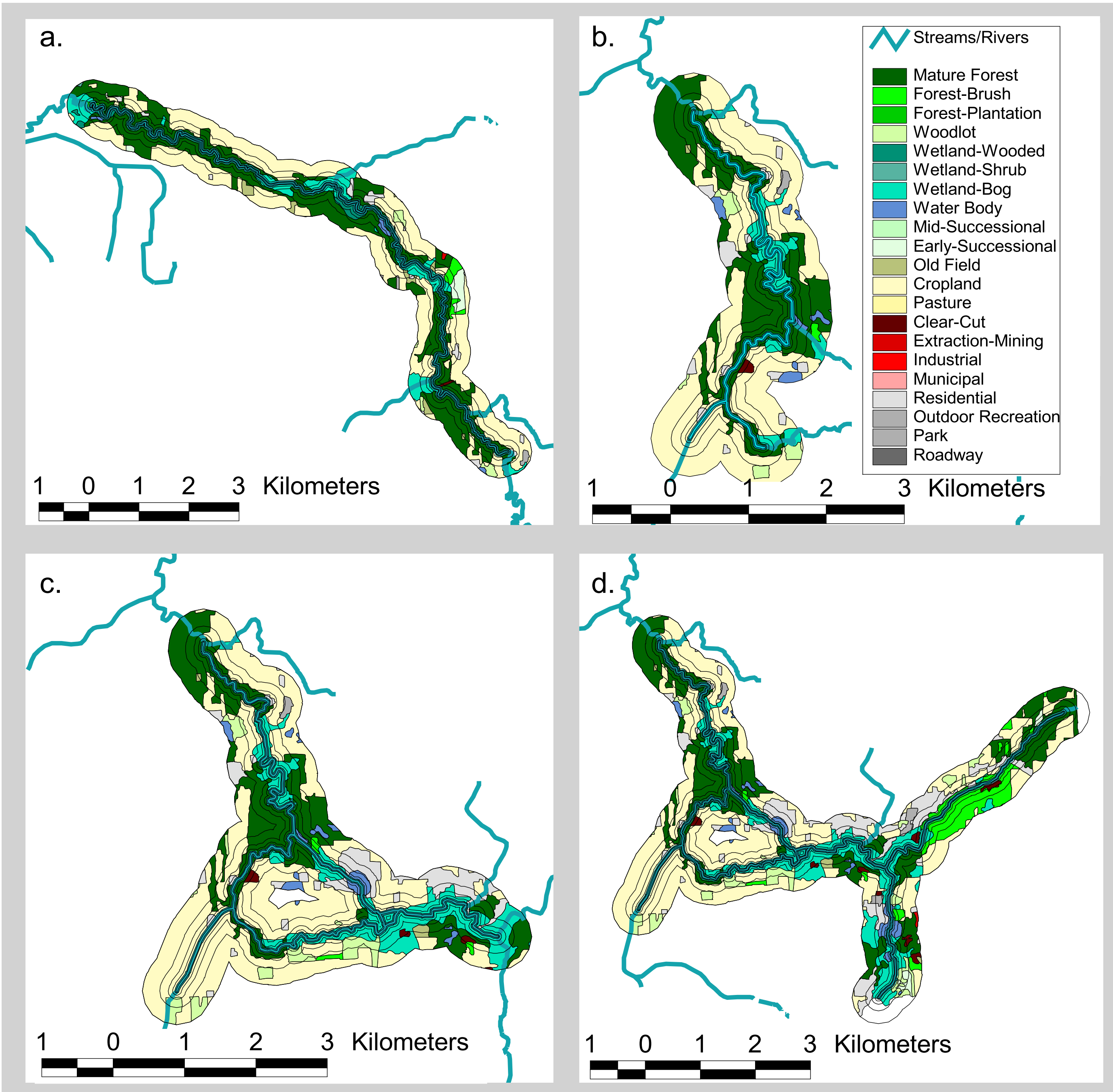

Figure 3. KZ250-500m site local (a), US-1 (b), U/S-2 (c) and U/S-3 (d) buffers areas within landscape contexts defined for spatial analysis. Land cover properties displayed are defined by the largest buffer width used for analysis (960m). Linework defining the 30, 60, 120, 240 and 480m buffers are also included.

Table 2. Natural community (C), animal (A), invertebrate (I) and rare plant (P) occurences documented during 2000 and 2001 riparian ecosystem surveys. Riparian width classes (<125m, 125-250m and 250-500m) and channel types (A, B and C) are indicated for each study site. Rivers include the Grand (GR), Kalamazoo (KZ), Raisin (RR), St. Joseph (SJ), Pine (PR), Maple (MR), Looking Glass (LG), Red Cedar (RC), Shiawassee (SH), Thornapple (TR) and Sycamore Creek (SC).

Site	Element	Type	State Status	Global/State rank
GR<125A	Prairie fen	C	-	G3/S3
	Carex trichocarpa	P	SC	G4/S2
	Pleurobema coccineum	I	SC	G4/S2S3
	Villosa iris	I	SC	G5/S2S3
	Blanding's Turtle	A	SC	G4/S3
GR125-250C	Southern floodplain forest	C	-	G3?/S3
GR250-500C	Southern floodplain forest	C	-	G3?/S3
	Carex squarrosa	P	SC	G4G5/S1
	Morus rubra	P	T	G5/S2
	Stylurus amnicola	I	SC	G4/S1S2
KZ<125A	*Alasmidonta viridis*	I	SC	G4G5/S2S3
	Pleurobema coccineum	I	SC	G4/S2S3
	Villosa iris	I	SC	G5/S2S3
KZ125-250A	*Pleurobema coccineum*	I	SC	G4/S2S3
	Villosa iris	I	SC	G5/S2S3
KZ250-500A	Southern floodplain forest	C	-	G3?/S3
	Lampsilis fasciola	I	T	G4/S1
	Pleurobema coccineum	I	SC	G4/S2S3
	Venustaconcha ellipsiformis	I	SC	G3G4/S2S3
	Villosa iris	I	SC	G5/S2S3
RR<125C	*Alasmidonta marginata*	I	SC	G4/S2S3
RR125-250A	*Cyclonaias tuberculata*	I	SC	G5/S2S3
	Lampsilis fasciola	I	T	G4/S1
	Notropis photogenis	A	E	G5/S1
	Pleurobema coccineum	I	SC	G4/S2S3
	Venustaconcha ellipsiformis	I	SC	G3G4/S2S3
	Villosa iris	I	SC	G5/S2S3
RR250-500A	Southern floodplain forest	C	-	G3?/S3
	Alasmidonta marginata	I	SC	G4/S2S3
	Lampsilis fasciola	I	T	G4/S1
	Pleurobema coccineum	I	SC	G4/S2S3
SJ<125B	*Pleurobema coccineum*	I	SC	G4/S2S3
	Villosa iris	I	SC	G5/S2S3
SJ125-250B	Southern floodplain forest	C	-	G3?/S3
	Fraxinus profunda	P	T	G4/S2
	Villosa iris	I	SC	G5/S2S3
SJ250-500B	*Alasmidonta marginata*	I	SC	G4/S2S3
	Venustaconcha ellipsiformis	I	SC	G3G4/S2S3
	Villosa iris	I	SC	G5/S2S3
	Euonymus atropurpurea	P	SC	G5/S3
PR<125A	*Gymnocladus dioicus*	P	SC	G5/S3S4
	Alasmidonta marginata	I	SC	G4/S2S3
PR125-250B	Southern floodplain forest	C	-	G3?/S3
	Alasmidonta marginata	I	SC	G4/S2S3
	Alasmidonta viridis	I	SC	G5/S2S3
	Pleurobema coccineum	I	SC	G4/S2S3
	Villosa iris	I	SC	G5/S2S3
PR250-500B	*Pleurobema coccineum*	I	SC	G4/S2S3
	Villosa iris	I	SC	G5/S2S3

Table 2. *Cont*.

Site	Element	Type	State Status	Global/State rank
SH<125B	*Gymnocladus dioicus*	P	SC	G5/S3S4
	Morus rubra	P	T	G5/S2
	Alasmidonta marginata	I	SC	G4/S2S3
	Pleurobema coccineum	I	SC	G4/S2S3
SH250-500A	Southern floodplain forest	C	-	G3?/S3
	Diarrhena americana	P	T	G4?/S2
	Euonymus atropurpurea	P	SC	G5/S3
	Gymnocladus dioicus	P	SC	G5/S3S4
	Lithospermum latifolium	P	SC	G4/S2
	Trillium nivale	P	T	G4/S2
	Alasmidonta marginata	I	SC	G4/S2S3
	Pleurobema coccineum	I	SC	G4/S2S3
	Venustaconcha ellipsiformis	I	SC	G3G4/S2S3
	Villosa iris	I	SC	G5/S2S3
LG<125A	*Euonymus atropurpurea*	P	SC	G5/S3
	Alasmidonta marginata	I	SC	G4/S2S3
	Pleurobema coccineum	I	SC	G4/S2S3
LG250-500C	*Lithospermum latifolium*	P	SC	G4/S2
	Alasmidonta marginata	I	SC	G4/S2S3
	Alasmidonta viridis	I	SC	G5/S2S3
	Venustaconcha ellipsiformis	I	SC	G3G4/S2S3
	Villosa iris	I	SC	G5/S2S3
MR<125C	*Fraxinus profunda*	P	T	G4/S2
	Alasmidonta marginata	I	SC	G4/S2S3
	Epioblasma triquetra	I	E	G3/S1
	Venustaconcha ellipsiformis	I	SC	G3G4/S2S3
MR125-250B	*Gymnocladus dioicus*	P	SC	G5/S3S4
	Fraxinus profunda	P	T	G4/S2
	Alasmidonta marginata	I	SC	G4/S2S3
	Alasmidonta viridis	I	SC	G5/S2S3
	Villosa iris	I	SC	G5/S2S3
MR250-500C	Southern floodplain forest	C	-	G3?/S3
	Carex davisii	P	SC	G4/S3
	Diarrhena americana	P	T	G4?/S2
RC<125B	*Alasmidonta marginata*	I	SC	G4/S2S3
	Venustaconcha ellipsiformis	I	SC	G3G4/S2S3
	Villosa iris	I	SC	G5/S2S3
RC125-250C	Southern floodplain forest	C	-	G3?/S3
	Carex davisii	P	SC	G4/S3
	Carex frankii	P	SC	G5/S2S3
	Diarrhena americana	P	T	G4?/S2
	Euonymus atropurpurea	P	SC	G5/S3
	Villosa iris	I	SC	G5/S2S3
	Venustaconcha ellipsiformis	I	SC	G3G4/S2S3
SC250-500B	Southern floodplain forest	C	-	G3?/S3
	Gymnocladus dioicus	P	SC	G5/S3S4
	Villosa iris	I	SC	G5/S2S3
TR125-250B	Southern floodplain forest	C	-	G3?/S3
	Diarrhena americana	P	T	G5/S2S3
	Euonymus atropurpurea	P	SC	G5/S3
	Pleurobema coccineum	I	SC	G4/S2S3
	Villosa iris	I	SC	G5/S2S3

trend towards increasing overall species richness with increasing riparian buffer width (Figure 4). There was no interaction indicated for this analysis (F=0.5, p>0.70). Total rare species richness was also not significantly different among riparian classes or channel types (F=0.8, p>0.45 and F=0.05, p>0.95, respectively), and there was no interaction between the factors (F=0.5, p>0.72). This was also true for rare species segregated into terrestrial (riparian, F=1.3, p>0.25; channel, F=0.3, p>0.7) and aquatic (riparian, F=0.3, p>0.75; channel, F=1.4, p>0.25) groups.

Aquatic Community Results

Aquatic community and ecological surveys were conducted at 27 riparian sites, including 12 sites in 2000 and 15 sites in 2001. Data collected during these surveys were used to calculate biological and ecological integrity parameters to serve as response variables for multiple statistical analyses used to detect potential relationships between aquatic communities and the riparian and channel properties of the sites surveyed. Aquatic ecological parameters calculated for these analyses are provided in Table 3.

Total HQI scores for sampled stream reaches ranged from a low score of 103 at a heavily impacted, previously dredged site (GR125-250) to a high score of 193 (out of 200) at the site within the Nature Conservancy Ives Road Fen Preserve (RR250-500). The mean (±1 SE) HQI score for all sites was 156±4.0, just below the 160 required to characterize the site as "optimal" using the HQI methodology (Barbour et al. 1999). Only 12 of the 27 (44%) of the streams associated with the riparian areas surveyed were scored as "optimal" using the HQI methodology (Table 3). Most of these streams were associated with 125-250m and 250-500m riparian areas with A or B channels, although a few optimal reaches were also associated with riparian areas <125m, and one was associated with a <125m riparian buffer and C channel combined (Table 3). There was no significant difference in mean HQI scores among riparian classes (F=0.12, p>0.88, Figure 5), although HQI scores were significantly lower for streams with C channels compared to streams with A and B channel types (F=9.0, p<0.003, Figure 6). There was no interaction between the main effects for the HQI ANOVA (F=0.8, p>0.53).

The mean total aquatic species richness (TASR) among sites was 89±3.8 species, ranging from a maximum of 115 species at the RR125-250 site to only 40 species at the MR250-500 site. Eleven of the 13

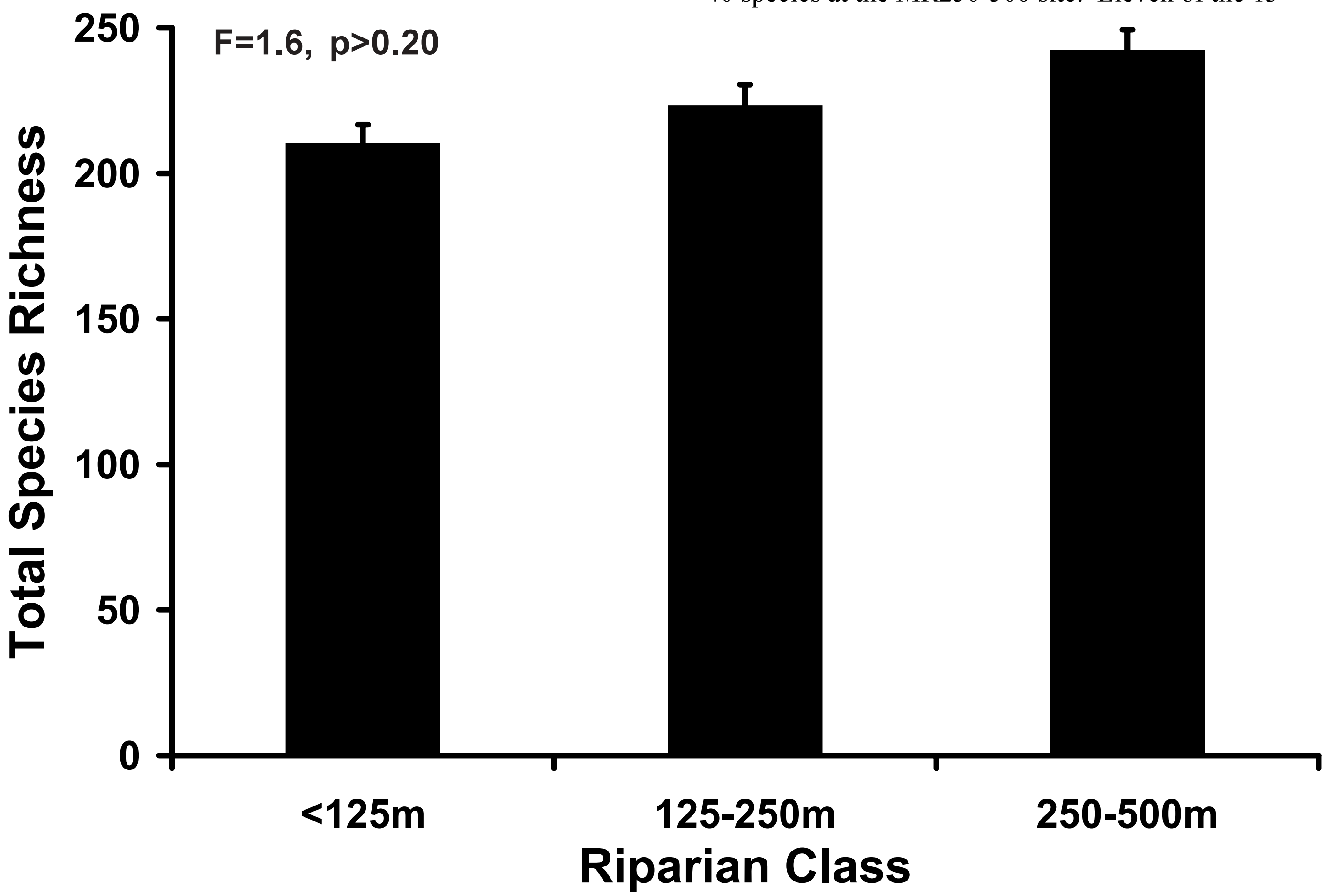

Figure 4. Total species richness (terrestrial and aquatic combined) among the three riparian width classes.

sites with TASR >95 species had <125m or 125-250m riparian corridors (Table 3), although no significant difference in mean TASR measures was detected among riparian classes ($F=2.5$, $p>0.10$, Figure 5). Mean TASR values were lower for sites with C vs. A channel types, although mean TASR for B channels was not significantly different from either A or C ($F=3.6$, $p>0.11$, Figure 6). No interaction was detected between riparian width class and channel type for the TASR ANOVA ($F=2.4$, $p>0.09$).

Fish community composition and species richness was variable in streams associated with the riparian forest corridor, and 52 fish species were observed among the 27 riparian sites sampled in 2000 and 2001 (Appendix I). Mean fish species richness (FSR) was not different among the riparian forest buffer width classes ($F=0.16$, $p>0.85$, Figure 7), although mean FSR was significantly lower for C channels compared to both A and B channel types ($F=5.6$, $p<0.015$, Figure 8). There was no significant interaction between riparian width class and channel type for the FSR ANOVA ($F=0.9$, $p>0.44$). Other fish community parameters were also not different among the riparian forest buffer width classes, including FCPUE ($F=0.4$, $p>0.67$), RAIF ($F=0.05$, $p>0.95$) and FIBI ($F=0.7$, $p>0.51$) (Figure 9). FCPUE measures were significantly higher for A channels compared to both B and C channel types ($F=6.2$, $p<0.01$, Figure 10), and mean FIBI values were lower at sites with C stream channels compared to both A and B channels ($F=10.4$, $p<0.002$, Figure 10). Mean RAIF measures exhibited a nearly significant decline across channel types ($F=3.2$, $p<0.065$). No interaction between the main effects was evident for the FCPUE ($F=0.4$, $p>0.82$), RAIF ($F=0.7$, $p>0.58$) and FIBI (1.3, $p>0.31$) ANOVAs.

A total of 25 native mussel species were detected during the riparian ecosystem surveys in 2000 and 2001 (Appendix II). Mussel species richness (MSR) and community composition ranged widely among sites sampled, including one site with no native unionids (GR125-250) and two sites with 13 mussel species each, the highest MSR recorded during the study (Appendix II). Mean MSR was not significantly different among the riparian width classes ($F=0.6$, $p>0.58$, Figure 7). However, MSR was significantly lower for C compared to both A and B channel types ($F=5.4$, $p<0.015$, Figure 8). There was no evidence to suggest a significant interaction between riparian width class and channel type for the MSR ANOVA ($F=2.2$, $p>0.11$). Mean MCPUE values were not different among riparian width classes ($F=1.7$, $p>0.20$) or channel types ($F=1.8$, $p>0.19$), and there was no interaction between the main effects for this analysis ($F=0.3$, $p>0.89$). The remaining mussel community parameters, including RATU, RAIU and MBTI, were not different among riparian width classes ($F=1.8$, $p>0.19$, $F=0.6$, $P>0.55$ and $F=1.8$, $p>0.19$, respectively, Figure 11), although they were significantly different among channel types. Mean RATU was significantly higher in C compared to both A and B channel types ($F=14.9$, $p<0.001$, Figure 12), mean RAIU was significantly higher in A compared to both B and C channel types ($F=8.9$, $p<0.003$, Figure 12), and mean MBTI scores were higher in C compared to both A and B channel types ($F=12.5$, $p<0.001$, Figure 12). No significant interactions between riparian width class and channel type were observed for the RAIU ($F=1.1$, $p>0.38$) or MBTI ($F=1.6$, $p>0.23$) analyses. However, there was significant evidence to suggest and interaction between the main effects for the RATU analysis ($F=4.1$, $p<0.02$), indicating that levels of response by RATU were inconsistent among the riparian width classes and channel types sampled.

Approximately 200 aquatic macroinvertebrate taxa were encountered during surveys of riparian ecosystems in 2000 and 2001. Appendices III and IV provide a complete inventory of the benthic macroinvertebrate taxa identified during the study. Benthic macroinvertebrates contributed the greatest number of species to total aquatic species richness measures for sites, ranging from 24 to 83 species, and often occurred in numbers 3-5 times greater than the number of fish and unionid species at a site. Because of this dominance in species richness, statistical test results of TASR at a site often followed those of the invertebrate analyses. Mean BNSR measures were nearly significantly different among the riparian forest buffer width classes, suggesting a trend towards declining BNSR with increasing riparian corridor width ($F=3.3$, $p<0.06$, Figure 7). Unlike most other aquatic community measures, mean BNSR was not significantly different among the channel types, although the data did indicate a non-significant trend towards declining BNSR with increasing incision of the stream channel ($F=1.7$, $p>0.20$, Figure 8). No interaction between riparian width class and channel type was indicated for the BNSR ANOVA ($F=1.0$, $p>0.40$). Benthic community indices, including EPT, FBI and RAIB, were not significantly different among riparian width classes ($F=2.4$, $p>0.12$, $F=0.4$, $p>0.65$ and $F=1.5$, $p>0.25$, respectively, Figure 13) or channel types ($F=1.4$, $p>0.25$, $F=0.9$, $p>0.45$ and $F=1.7$, $p>0.21$, respectively, Figure 14). There was no interaction between riparian width class and channel type for the EPT, FBI or RAIB ANOVAs ($F=1.9$, $p>0.14$, $F=0.6$, $p>0.64$ and $=0.8$, $p>0.53$, respectively).

Table 3. Summary of habitat, fish, mussel and benthic macroinvertebrate community indices for 27 riparian sites in southern Lower Michigan sampled in 2000 and 2001. Indices include Habitat Quality Index (HQI), total aquatic species richness (TASR), fish species richness (FSR), relative abundance of intolerant fish (RAIF), fish catch per unit effort (FCPUE), fish IBI (FIBI), benthic invertebrate species richness (BNSR), Ephemeroptera, Plecoptera and Trichoptera Index (EPT), benthic invertebrate biotic index (INBI), relative abundance of intolerant benthos (RAIB), mussel species richness (MSR), relative abundance of intolerant unionids (RAIU), relative abundance of tolerant unionids (RATU) and Mussel Biotic Tolerance Index (MBTI). Increasing values for HBI, FIBI, INBI and EPT reflect greater biological integrity, while larger MBTI scores reflect greater community tolerance to degraded environmental conditions. RAIF, RAIB and RAIU are expected to increase with increasing site ecological integrity, while RATU values are expected to increase with increasing levels of environmental degradation at a site. Channel types include shallow (A), moderately incised (B) and deeply incised (C).

Site	Riparian Class	Channel Type	HQI	TASR	FSR	RAIF	FCPUE	FIBI	BNSR	EPT	FBI	RAIB	MUSR	RAIU	RATU	MBTI
Grand	**<125m**	**SH**	**175**	**108**	**20**	**0.38**	**1.6**	**46**	**82**	**22**	**5.5**	**0.05**	**6**	**0.50**	**0.04**	**1.75**
Kalamazoo	**<125m**	**SH**	**154**	**106**	**20**	**0.33**	**4.2**	**44**	**77**	**22**	**5.4**	**0.04**	**9**	**0.37**	**0.00**	**1.82**
Pine	**<125m**	**SH**	**158**	**84**	**24**	**0.12**	**1.7**	**38**	**51**	**20**	**5.1**	**0.00**	**9**	**0.12**	**0.29**	**2.22**
Red Cedar	**<125m**	**MI**	**150**	**78**	**21**	**0.23**	**1.8**	**36**	**46**	**12**	**5.3**	**0.00**	**11**	**0.27**	**0.19**	**2.51**
Shiawassee	**<125m**	**MI**	**172**	**112**	**21**	**0.26**	**1.8**	**44**	**82**	**37**	**3.8**	**0.18**	**9**	**0.18**	**0.33**	**2.36**
St. Joseph	**<125m**	**MI**	**157**	**96**	**20**	**0.13**	**2.1**	**48**	**70**	**27**	**4.8**	**0.02**	**6**	**0.04**	**0.02**	**1.93**
Looking Glass	**<125m**	**DI**	**165**	**107**	**17**	**0.10**	**1.4**	**34**	**82**	**37**	**4.6**	**0.00**	**8**	**0.10**	**0.40**	**2.80**
Maple	**<125m**	**DI**	**152**	**108**	**21**	**0.13**	**2.0**	**42**	**76**	**25**	**4.7**	**0.00**	**11**	**0.26**	**0.11**	**2.14**
Raisin	**<125m**	**DI**	**126**	**83**	**18**	**0.10**	**1.3**	**38**	**57**	**20**	**5.8**	**0.10**	**8**	**0.00**	**0.46**	**3.07**
Kalamazoo	**125-250m**	**SH**	**164**	**95**	**19**	**0.27**	**2.5**	**42**	**72**	**26**	**5.0**	**0.09**	**4**	**0.60**	**0.00**	**1.60**
Looking Glass	**125-250m**	**SH**	**169**	**111**	**21**	**0.20**	**5.2**	**38**	**77**	**31**	**4.6**	**0.09**	**13**	**0.54**	**0.07**	**1.55**
Raisin	**125-250m**	**SH**	**182**	**115**	**22**	**0.20**	**1.6**	**47**	**83**	**40**	**4.7**	**0.19**	**10**	**0.33**	**0.00**	**1.97**
Maple	**125-250m**	**MI**	**163**	**104**	**20**	**0.34**	**2.9**	**48**	**75**	**26**	**3.6**	**0.29**	**9**	**0.05**	**0.29**	**2.52**
Pine	**125-250m**	**MI**	**173**	**94**	**19**	**0.25**	**2.1**	**40**	**65**	**23**	**4.6**	**0.01**	**10**	**0.12**	**0.03**	**2.01**
St. Joseph	**125-250m**	**MI**	**140**	**99**	**23**	**0.12**	**1.5**	**44**	**65**	**25**	**6.4**	**0.06**	**11**	**0.12**	**0.11**	**1.60**
Grand	**125-250m**	**DI**	**103**	**52**	**6**	**0.00**	**0.5**	**28**	**46**	**17**	**5.0**	**0.00**	**0**	**0.00**	**1.00**	**4.00**
Red Cedar	**125-250m**	**DI**	**142**	**82**	**13**	**0.51**	**1.4**	**34**	**62**	**21**	**5.1**	**0.01**	**7**	**0.16**	**0.01**	**1.90**
Thornapple	**125-250m**	**DI**	**145**	**59**	**15**	**0.06**	**1.2**	**30**	**38**	**12**	**7.3**	**0.00**	**6**	**0.02**	**0.08**	**2.13**
Kalamazoo	**250-500m**	**SH**	**163**	**100**	**17**	**0.19**	**3.0**	**44**	**76**	**25**	**5.2**	**0.01**	**7**	**0.56**	**0.00**	**1.53**
Raisin	**250-500m**	**SH**	**193**	**79**	**20**	**0.57**	**4.1**	**46**	**48**	**19**	**4.1**	**0.01**	**11**	**0.03**	**0.02**	**2.03**
Shiawassee	**250-500m**	**SH**	**183**	**87**	**26**	**0.32**	**1.3**	**48**	**48**	**23**	**4.1**	**0.12**	**13**	**0.13**	**0.11**	**2.61**
Pine	**250-500m**	**MI**	**172**	**87**	**20**	**0.21**	**0.6**	**38**	**55**	**19**	**5.1**	**0.01**	**12**	**0.37**	**0.05**	**2.07**
St. Joseph	**250-500m**	**MI**	**158**	**98**	**25**	**0.22**	**1.3**	**50**	**63**	**19**	**5.1**	**0.03**	**10**	**0.16**	**0.02**	**1.91**
Sycamore Creek	**250-500m**	**MI**	**135**	**56**	**9**	**0.08**	**2.1**	**28**	**43**	**14**	**4.2**	**0.03**	**4**	**0.03**	**0.00**	**2.00**
Grand	**250-500m**	**DI**	**124**	**76**	**13**	**0.09**	**0.8**	**26**	**60**	**18**	**6.1**	**0.02**	**3**	**0.00**	**1.00**	**3.83**
Maple	**250-500m**	**DI**	**158**	**40**	**14**	**0.02**	**0.9**	**30**	**24**	**5**	**4.8**	**0.00**	**2**	**0.00**	**1.00**	**4.00**
Shiawassee	**250-500m**	**DI**	**127**	**79**	**19**	**0.14**	**1.1**	**34**	**58**	**24**	**4.1**	**0.01**	**2**	**0.00**	**1.00**	**3.40**

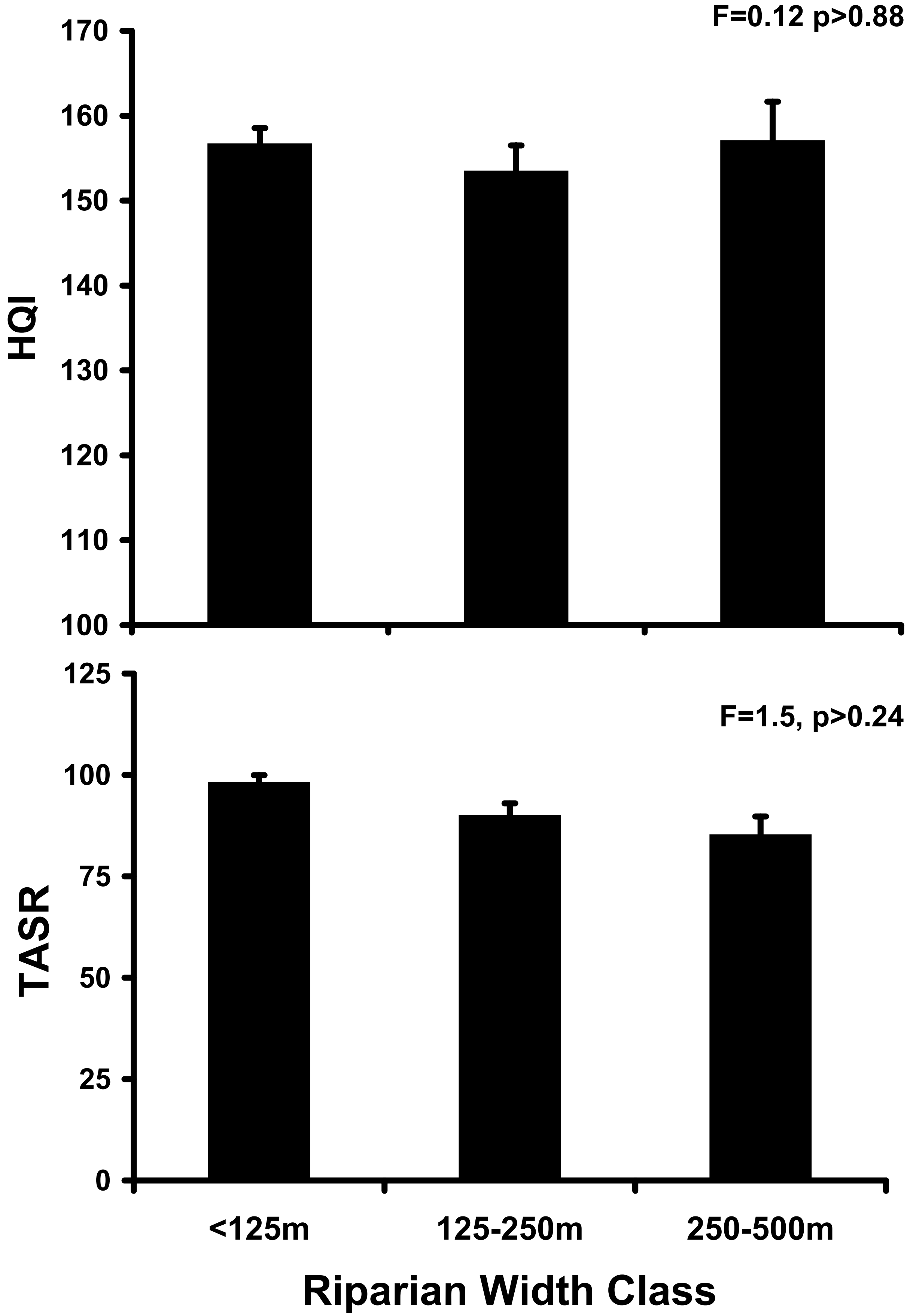

Figure 5. Comparisons of the mean (±1 S.E.) Habitat Quality Index (HQI) and total aquatic species richness (TASR) among streams characterized by three riparian width classes. Similarly colored bars reflect means that were not significantly different at α=0.05.

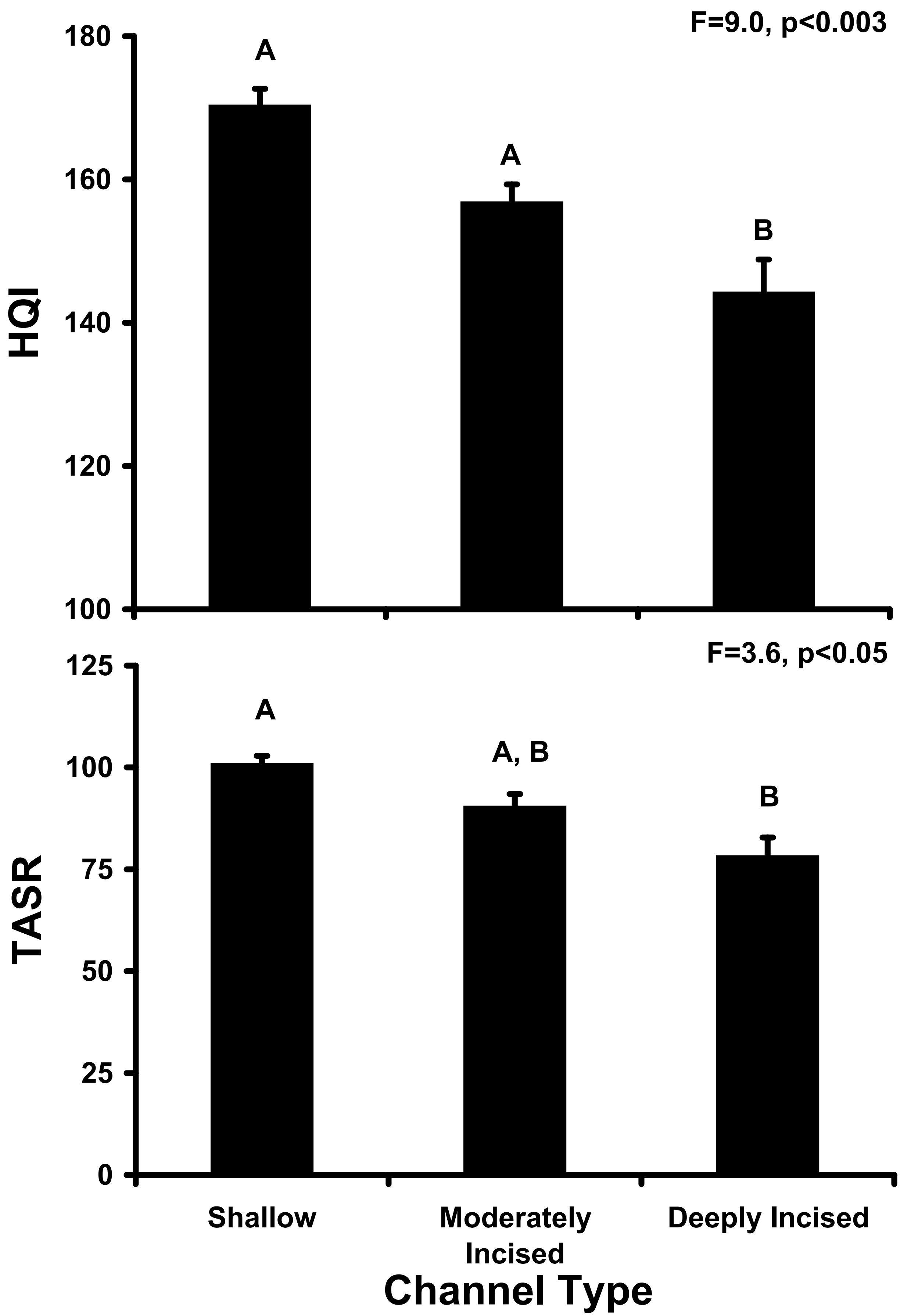

Figure 6. Comparisons of the mean (±1 S.E.) Habitat Quality Index (HQI) and total aquatic species richness (TASR) among streams characterized by three channel types. Letters reflect means that were not significantly different at $\alpha=0.05$.

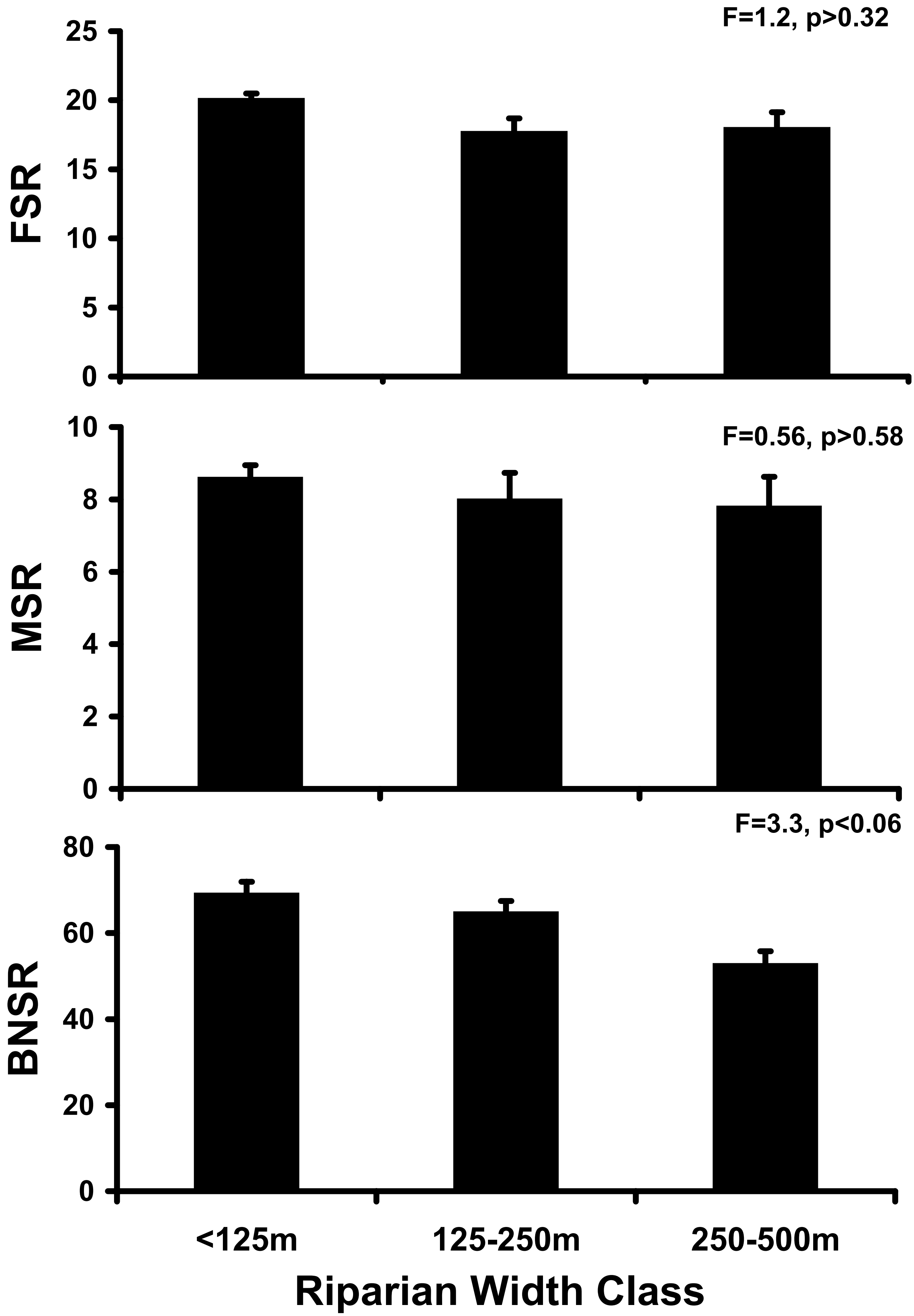

Figure 7. Comparisons of the mean (±1 S.E.) number of native fish species (FSR), native mussel species (MSR) and benthic species (BNSR) observed among streams characterized by three riparian width types. Similarly colored bars reflect means that were not significantly different at α=0.05.

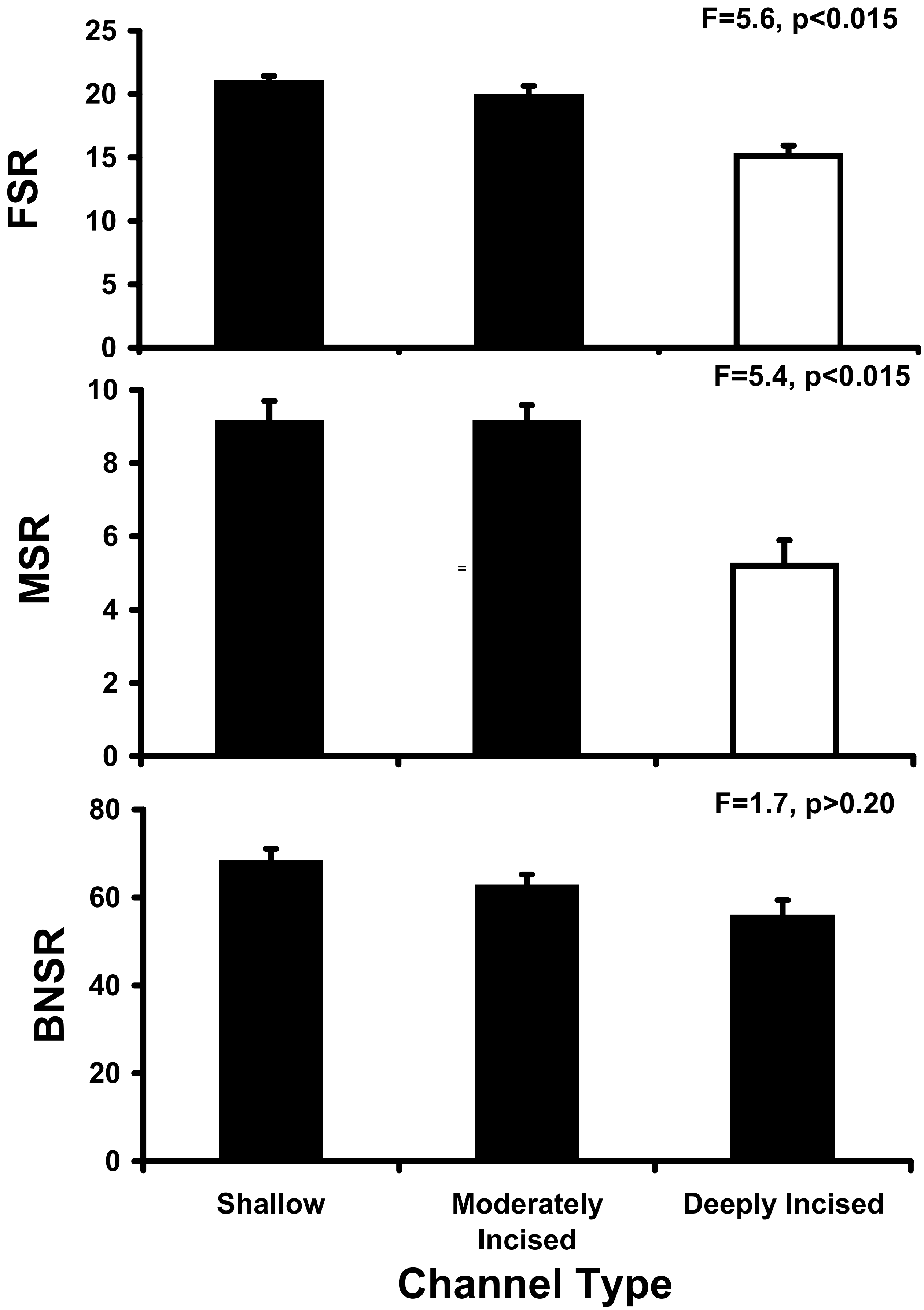

Figure 8. Comparisons of the mean (±1 S.E.) number of native fish species (FSR), native mussel species (MSR) and benthic species (BNSR) observed among streams characterized by three channel types. Similarly colored bars reflect means that were not significantly different at α=0.05.

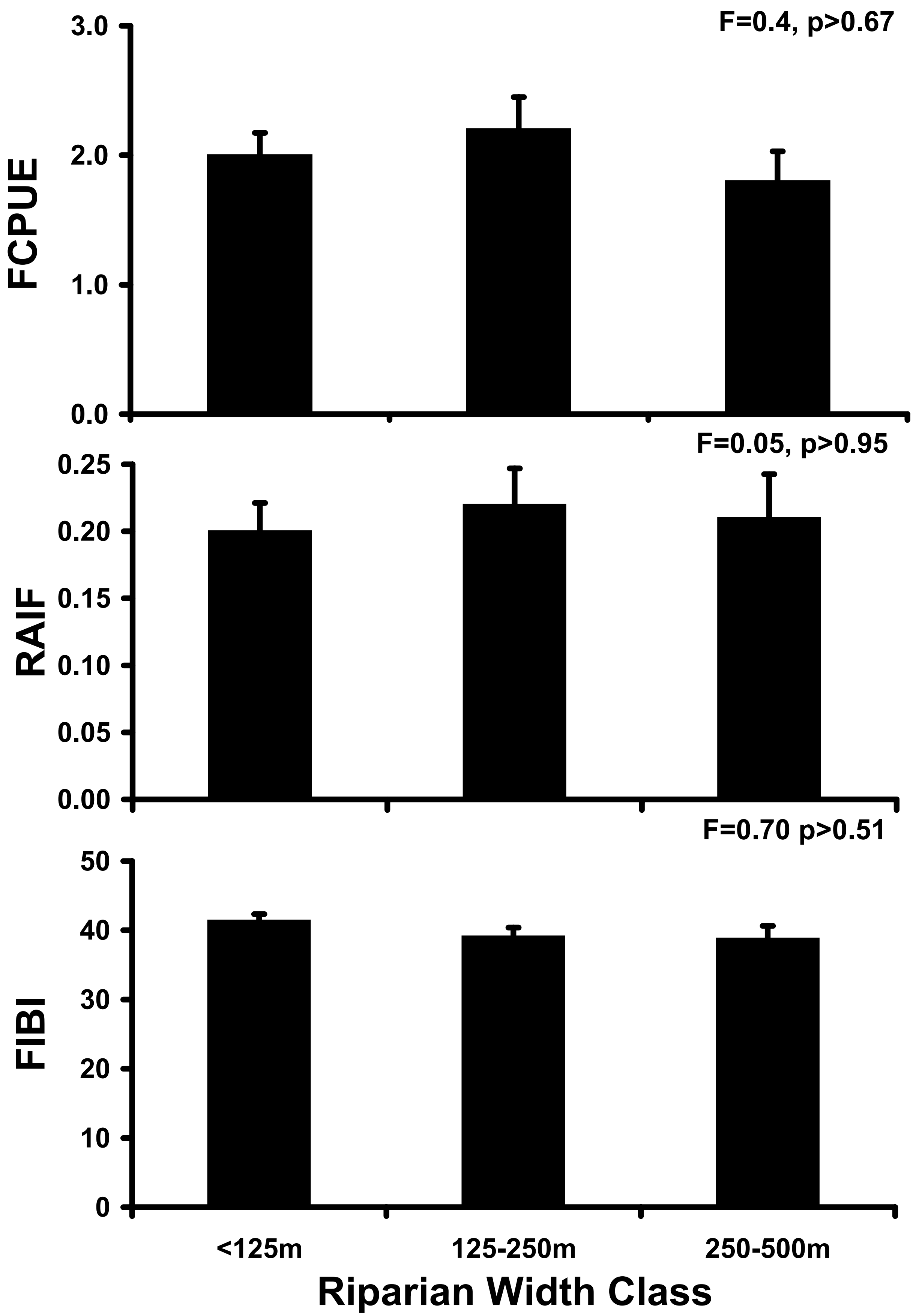

Figure 9. Comparisons of the mean (±1 S.E.) fish catch per unit effort (CPUE), relative abundance of intolerant fish (RAIF), and the fish index of biotic integrity (FIBI) observed among the three riparian width classes sampled. Similarly colored bars reflect means that were not significantly different at α=0.05.

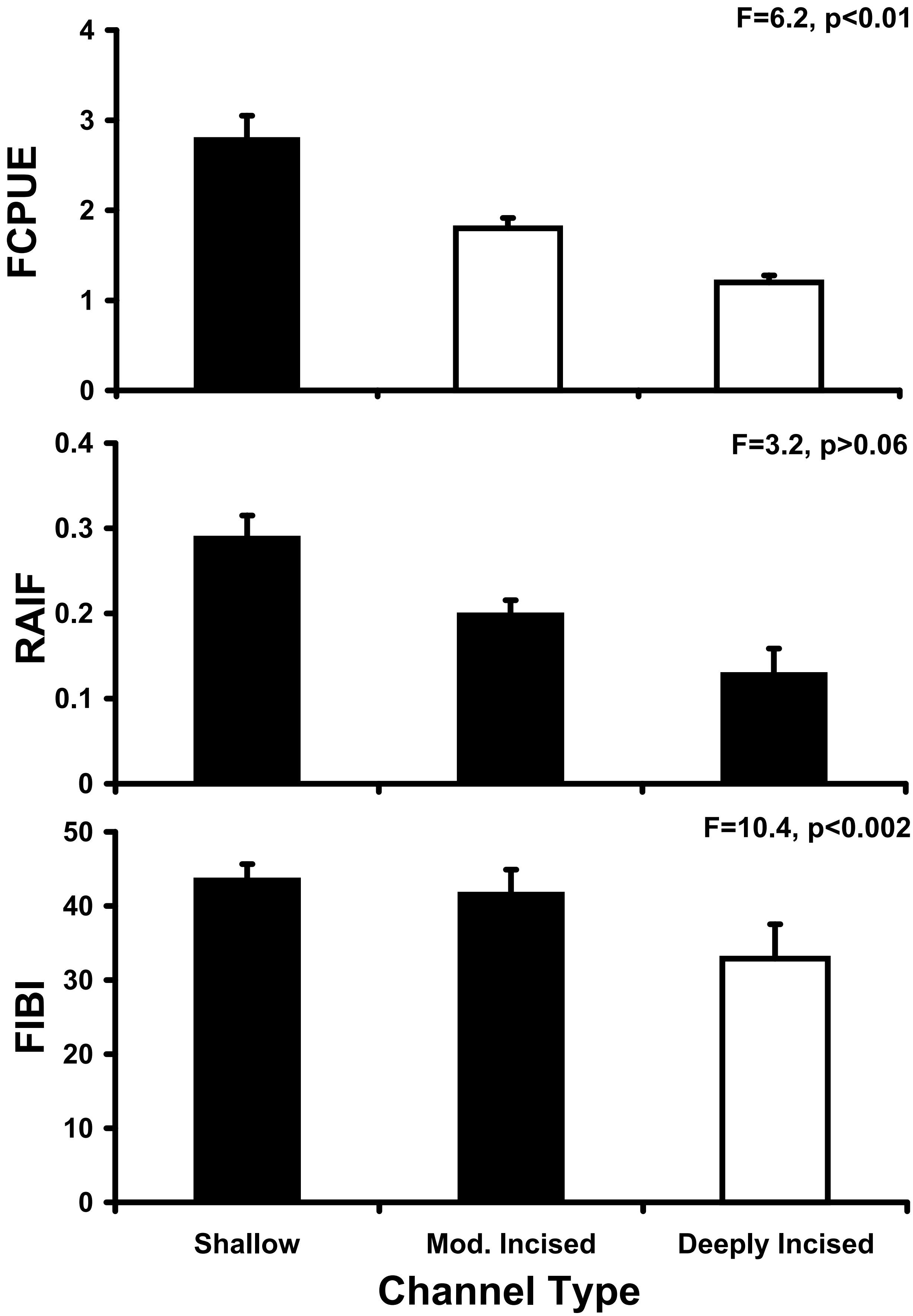

Figure 10. Comparisons of the mean (±1 S.E.) fish catch per unit effort (FCPUE), relative abundance of intolerant fish (RAIF), and the fish index of biotic integrity (FIBI) observed among the three channel types sampled. Similarly colored bars reflect means that were not significantly different at α=0.05.

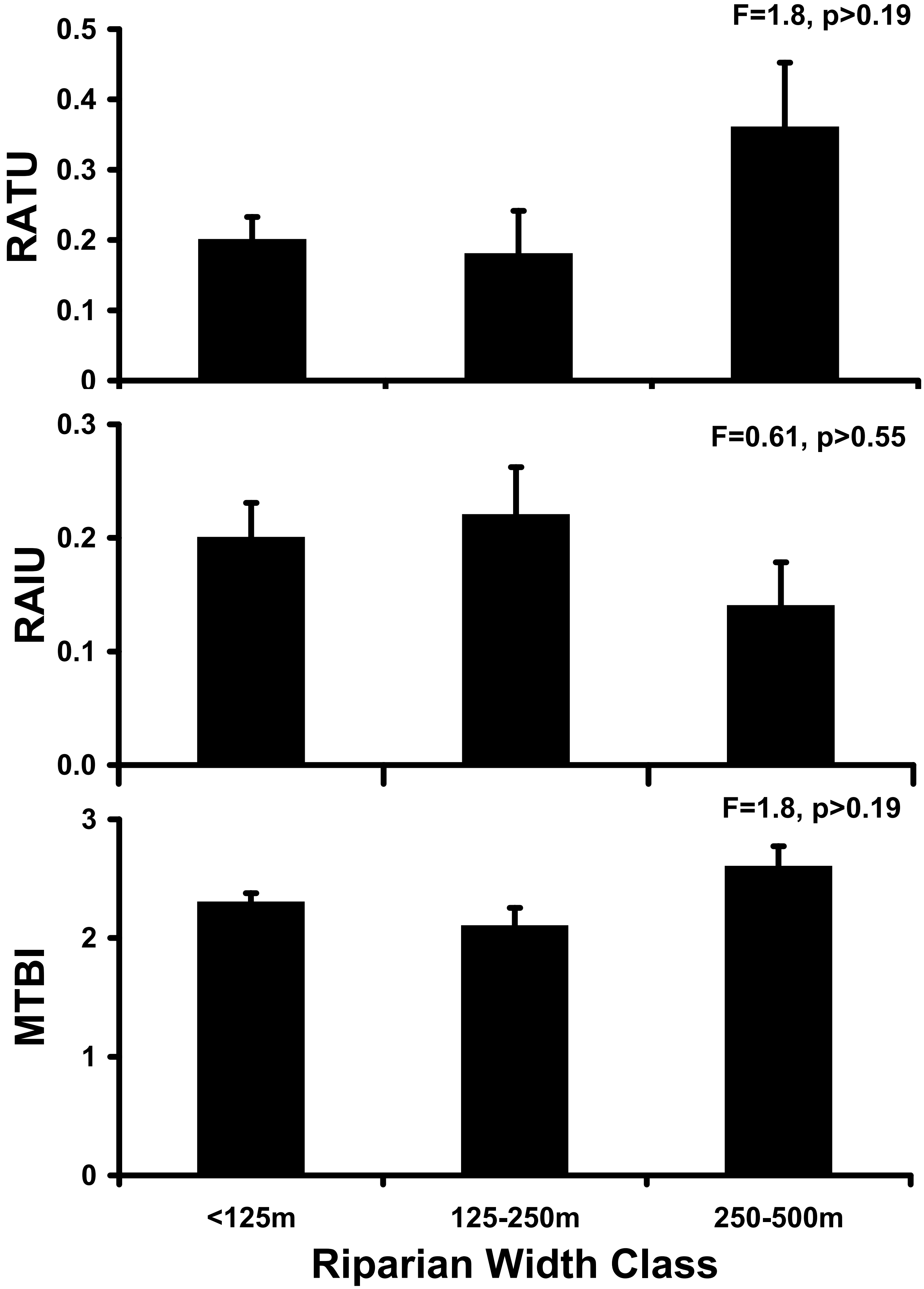

Figure 11. Comparisons of the mean (±1 S.E.) native mussel relative abundance of tolerant unionids (RATU), relative abundance of intolerant unionids (RAIU) and mussel biotic tolerance index (MBTI) observed among streams characterized by three riparian width classes. Similarly colored bars reflect means that were not significantly different at α=0.05.

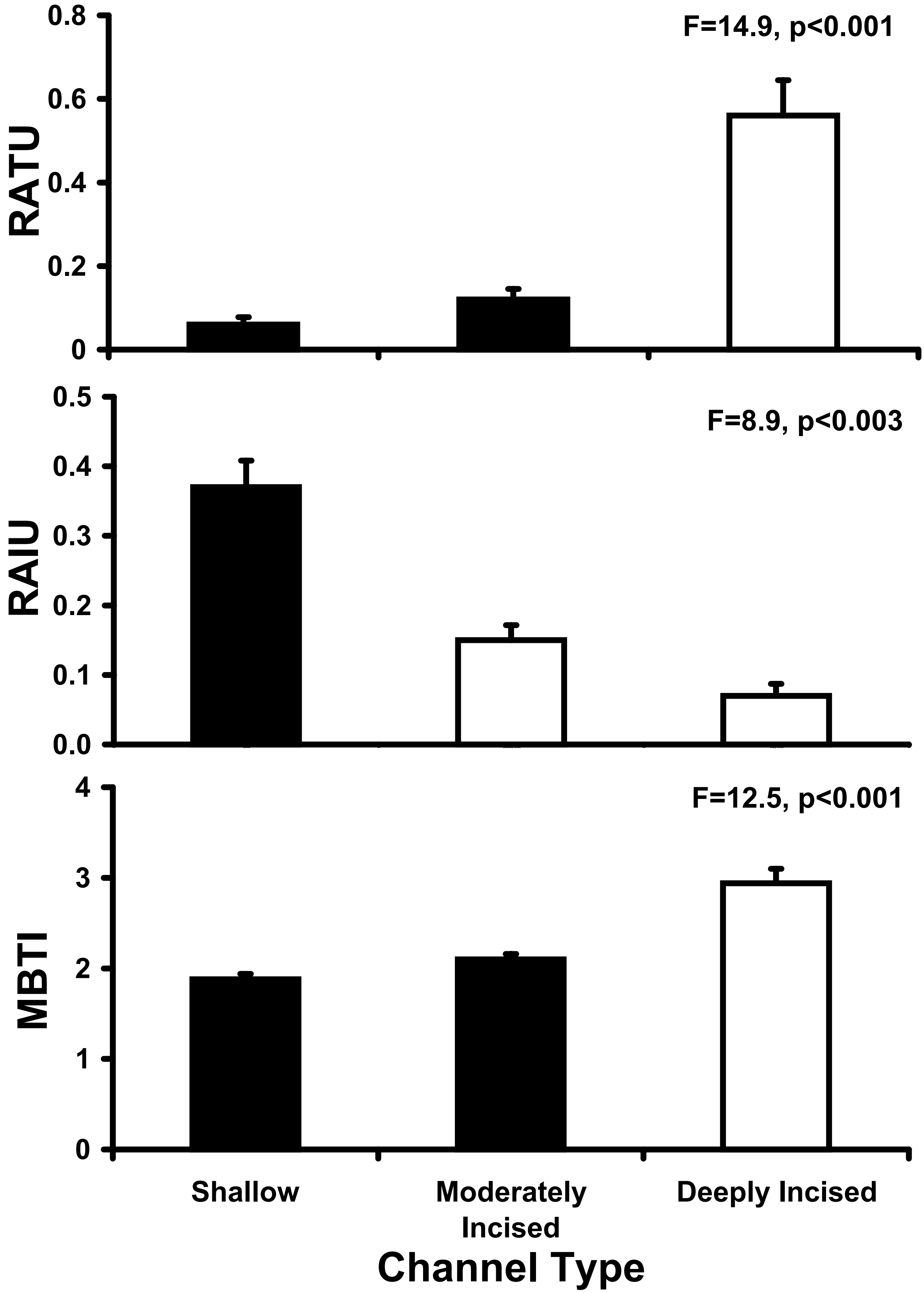

Figure 12. Comparisons of the mean (±1 S.E.) native mussel catch per unit effort (MPCUE), relative abundance of intolerant unionids (RAIU) and mussel biotic tolerance index (MBTI) observed among streams characterized by three channel types. Similarly colored bars reflect means that were not significantly different at α=0.05.

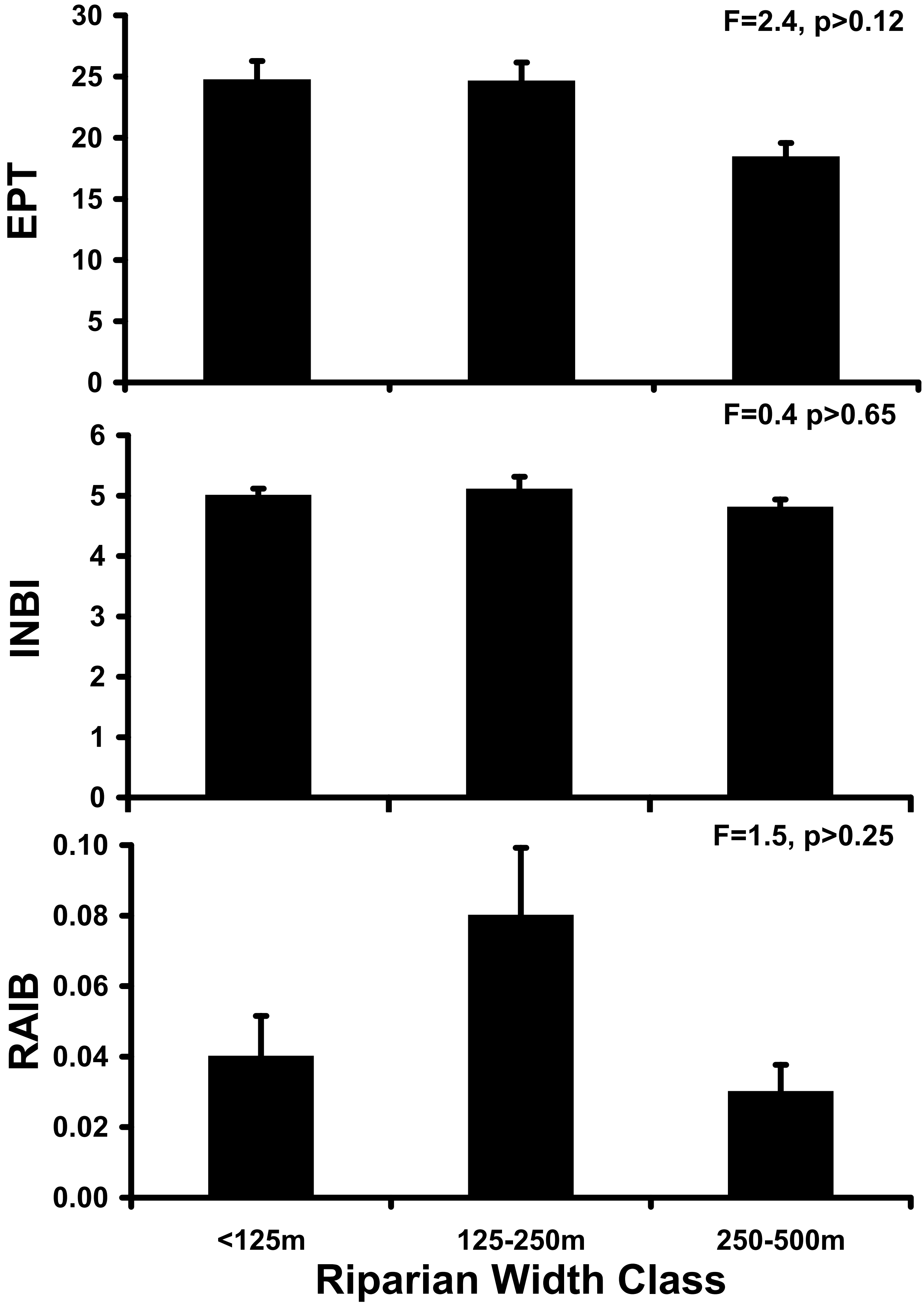

Figure 13. Comparisons of the mean (±1 S.E.) benthic Ephemeroptera-Plecoptera-Trichoptera index (EPT), Benthic Invertebrate Biotic Index (INBI) and relative abundance of intolerant benthos (RAIB) observed among the three riparian width classes sampled. Similarly colored bars reflect means that were not significantly different at α=0.05.

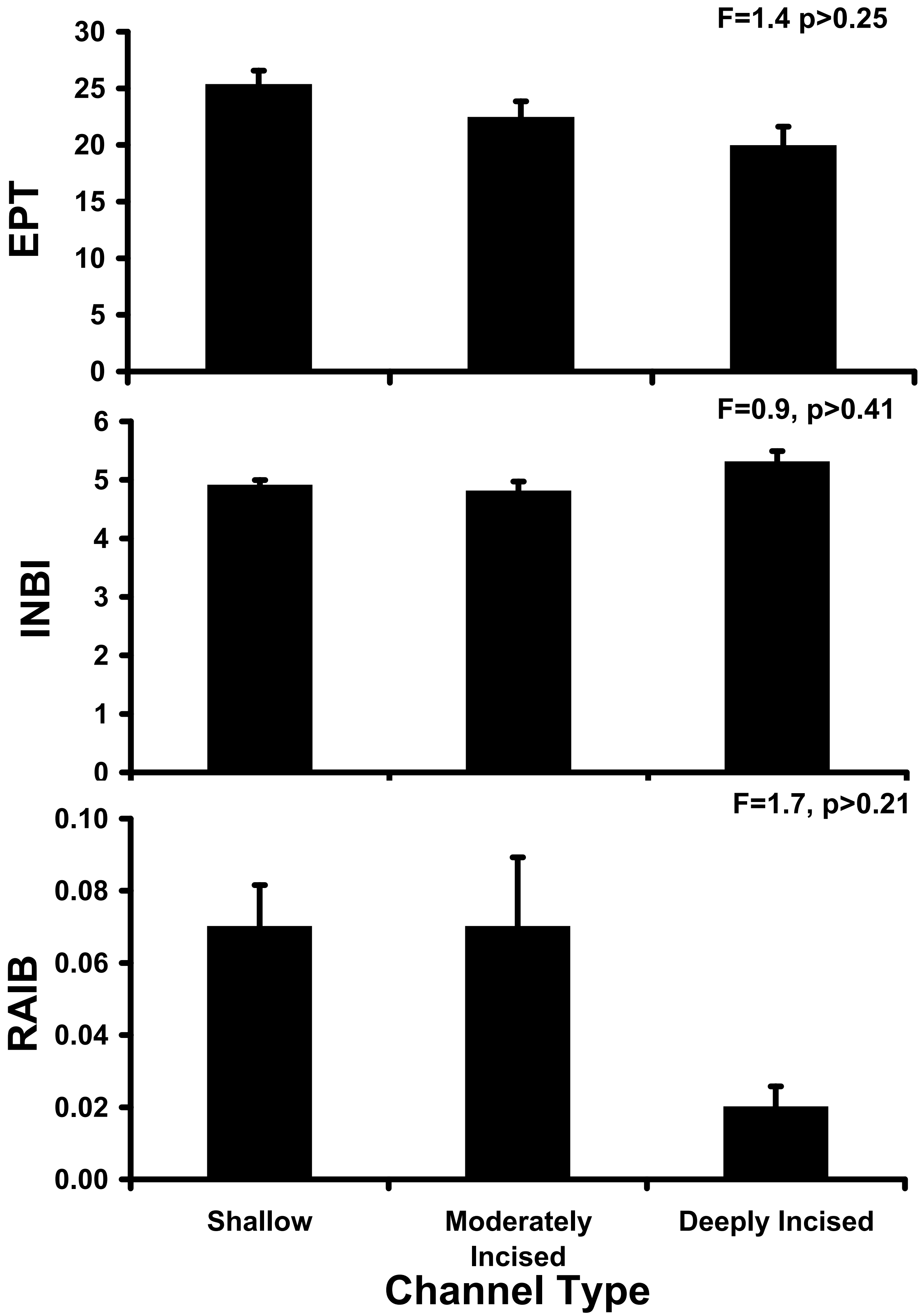

Figure 14. Comparisons of the mean (±1 S.E.) benthic Ephemeroptera-Plecoptera-Trichoptera (EPT), Benthic Invertebrate Biotic Index (INBI) and relative abundance of intolerant benthos (RAIB) observed among the three channel types sampled. Similarly colored bars reflect means that were not significantly different at α=0.05.

Correlation analysis was used to detect associations among aquatic ecological parameters independent from the riparian width classes and channel types. Many of the significant associations detected reflected autocorrelated data (e.g., community parameters based on data for the same taxonomic group) (Table 4). Of greatest interest was the existence of significant correlations between aquatic community parameters for different taxonomic groups and between aquatic community parameters and HQI scores. Several aquatic community parameters were positively correlated with site HQI scores, including TASR ($R=0.54$, $p<0.005$, Figure 15), FSR ($R=0.63$, $p<0.001$, Figure 16), RAIF ($R=0.57$, $p<0.003$, Figure 16), FIBI ($R=0.66$, $p<0.001$, Figure 16) and MSR ($R=0.63$, $p<0.001$, Figure 17). MBTI scores and RATU values were both negatively correlated with HQI scores ($R=-0.54$, $p<0.005$ and $R=-0.59$, $p<0.002$, respectively, Figure 17). No benthic community parameters were significantly associated with site HQI scores (Table 4). Several fish, mussel and benthic community measures also exhibited significant associations, including FSR and MSR ($R=0.76$, $p<0.001$, Figure 17), FIBI and MSR ($R=0.60$, $p<0.002$), FIBI and RATU ($R=-0.60$, $p<0.002$), FIBI and MBTI ($R=-0.59$, $p<0.002$, Figure 17), FCPUE and MBTI ($R=-0.55$, $p<0.004$), FIBI and BNSR ($R=0.54$, $p<0.004$, Figure 17), and RAIF and BNSR ($R=0.55$, $p<0.004$).

Vegetation and Floristic Results

Overall Vegetation and Floristic Sampling Summary

A complete catalog of the vascular plant species identified during the study, with separate listings for native and non-native (adventive) species, is provided in Appendices V and VI. Total floristic diversity for each study site, including the number and proportion of native and non-native species, is shown in Table 5. Site FQI scores and $\bar{C}$ values are also provided in Table 5. Site FQI values ranged from 31.1 to a high of 54.9, whereas site $\bar{C}$ values ranged from 2.9 to 4.2, with a median value of 3.7. Fifty percent of the sampling sites had values of 3.7 and higher, while the remaining site scores ranged from 2.9 to 3.7 (Figure 18). A total of 544 plant species was compiled from the 27 study sites surveyed during vegetation and floristic sampling from 2000-2001. Of this total, 475 species (87.5%) were native and 69 (12.5%) were non-native (adventive) species.

The native species observed included 63 trees, 39 shrubs, eight woody vines, 202 perennial forbs, six biennial forbs, 31 annual forbs, 31 perennial grasses, 65 perennial sedges and 25 ferns and fern-allies (clubmosses and horsetails). The adventive species observed included 10 trees, 11 shrubs, 21 perennial forbs, seven biennial forbs, seven annual forbs, nine perennial grasses, and three annual grasses.

Three native tree species and two native woody vines were common to prevalent at all 27 study sites, including *Acer saccharinum* (silver maple), *Fraxinus pennsylvanica* (green ash), *Ulmus americana* (American elm), *Parthenocissus quinquefolia* (Virginia creeper) and *Toxicodendron radicans* (poison ivy). Forbs found at all study sites included *Aster lateriflorus* (side flowering aster), *Boehmeria cylindrica* (false nettle), *Laportea canadensis* (wood nettle) and *Viola sororia* (common blue violet). Species that were found at approximately 80% or more sites (at least 22 of 27 study sites) included such characteristic floodplain forest woody plants as *Carya cordiformis* (bitternut hickory), *Populus deltoides* (Eastern cottonwood), *Tilia americana* (American basswood), *Fraxinus americana* (white ash), *Rubus occidentalis* (black raspberry), *Quercus bicolor* (swamp white oak), *Q. macrocarpa* (bur oak), *Carpinus caroliniana* (blue-beech or ironwood), *Prunus virginiana* (chokecherry), *Vitis riparia* (riverbank grape), *Zanthoxylum americanum* (prickly ash), and *Crataegus* spp. (hawthorn).

Prevalent, characteristic forbs (those occurring in at least 80% or more sites) other than those noted above included *Arisaema triphyllum* (Jack-in-the-pulpit), *Carex amphibola* (sedge), *C. grayi* (Gray's sedge), *Circaea lutetiana* (enchanter's nightshade), *Elymus virginicus* (Virginia wild rye), *Galium aparine* (cleavers), *Geranium maculatum* (wild geranium), *Geum canadense* (white avens), *Impatiens capensis* (touch-me-not), *Iris virginica* (southern blue-flag), *Leersia virginica* (white grass), *Onoclea sensibilis* (sensitive fern), *Podophyllum peltatum* (Mayapple), *Polygonum virginianum* (jumpseed), *Solidago gigantea* (late goldenrod), *Ranunculus hispidus* (swamp buttercup).

Site occurrence frequencies for all species are provided in Figure 19. Species occurring in samples from a majority of the sampling sites, defined here as 22 or more of the 27 study sites (81%), comprised just under 8% of the 544 taxa identified during our surveys. Only 96 species (17.6%) were found in 50% or more (i.e., 14 or more) of the study sites. Thus, 448 species (82.4%) were found in 13 or fewer sites, and most notably, 155 species (28.5%) were found in only one study site, and just over half of all species catalogued occurred in three or fewer sites.

Natural Community and Rare Species Occurrences

Twelve natural community occurrences and 27 rare plant occurrences were documented during study site surveys from 2000-2001 (Table 2). One

Table 4. Spearman's Rank correlation coefficients (R) and two-tailed statistical significance values (p) for correlations between aquatic community descriptors of the 27 riparian survey sites. Correlations with p<0.005 are highlighted in light gray. Correlations for autocorrelated data are indicated in dark gray. Community descriptors include Habitat Quality Index (HQI, Barbour et al. 1999), fish species richness (FSR), fish Index of Biotic Integrity (FIBI, Karr 1981) relative abundance of intolerant fish (RAIF), fish catch per unit effort (FCPUE), mussel species richness (MSR), relative abundance of intolerant unionids (RAIU), relative abundance of tolerant unionids (RATU), mussel catch per unit effort (MCPUE), mussel biotic tolerance index (MBTI), benthic species richness (BNSR), Benthic Invertebrate Biotic Index (INBI), relative abundance of intolerant benthos (RAIB), Ephemerotpera, Plecoptera and Trichoptera Index (EPT), and total aquatic species richness (TASR).

	HQI		FSR		FIBI		RAIF		FCPUE		MSR		RAIU	
	R	p	R	p	R	p	R	p	R	p	R	p	R	p
HQI	.	.	0.63	<0.001	0.66	<0.001	0.57	0.002	0.42	0.03	0.63	<0.001	0.43	0.02
FSR			.	.	0.78	<0.001	0.34	0.08	0.25	0.21	0.76	<0.001	0.31	0.12
FIBI					.	.	0.53	0.004	0.38	0.05	0.6	0.001	0.37	0.06
RAIF							.	.	0.46	0.02	0.42	0.03	0.29	0.14
FCPUE									.	.	0.39	0.04	0.45	0.02
MUSR											.	.	0.31	0.12
RAIU													.	.
RATU														

Table 4. ***Cont.***

	RATU		MCPU		MBTI		BNSR		INBI		RAIB		EPT	
	R	p	R	p	R	p	R	p	R	p	R	p	R	p
HQI	-0.59	0.001	0.47	0.01	-0.54	0.004	0.32	0.11	-0.39	0.05	0.3	0.13	0.38	0.05
FSR	-0.45	0.02	0.31	0.12	-0.47	0.01	0.35	0.07	-0.13	0.53	0.31	0.12	0.38	0.05
FIBI	-0.6	0.001	0.38	0.05	-0.59	0.001	0.54	0.003	-0.29	0.14	0.48	0.01	0.48	0.01
RAIF	-0.51	0.007	0.26	0.19	-0.47	0.01	0.28	0.16	-0.32	0.1	0.25	0.21	0.17	0.39
FCPUE	-0.47	0.01	0.34	0.08	-0.55	0.003	0.38	0.05	-0.27	0.18	0.2	0.31	0.27	0.18
MUSR	-0.65	<0.001	0.59	0.001	-0.58	0.002	0.3	0.13	-0.12	0.55	0.26	0.19	0.34	0.08
RAIU	-0.52	0.005	0.33	0.09	-0.63	0	0.55	0.003	0.04	0.86	0.11	0.59	0.33	0.09
RATU	.	.	-0.51	0.006	0.94	<0.001	-0.37	0.06	-0.01	0.95	-0.14	0.49	-0.27	0.18
MCPUE			.	.	-0.48	0.01	0.41	0.04	-0.09	0.67	0.45	0.02	0.44	0.02
MBTI					.	.	-0.48	0.01	-0.05	0.8	-0.12	0.56	-0.35	0.08
BenSR							.	.	-0.19	0.35	0.43	0.03	0.86	<0.001
FBI									.	.	-0.4	0.04	-0.36	0.06
RAIB											.	.	0.51	0.006
EPT													.	.

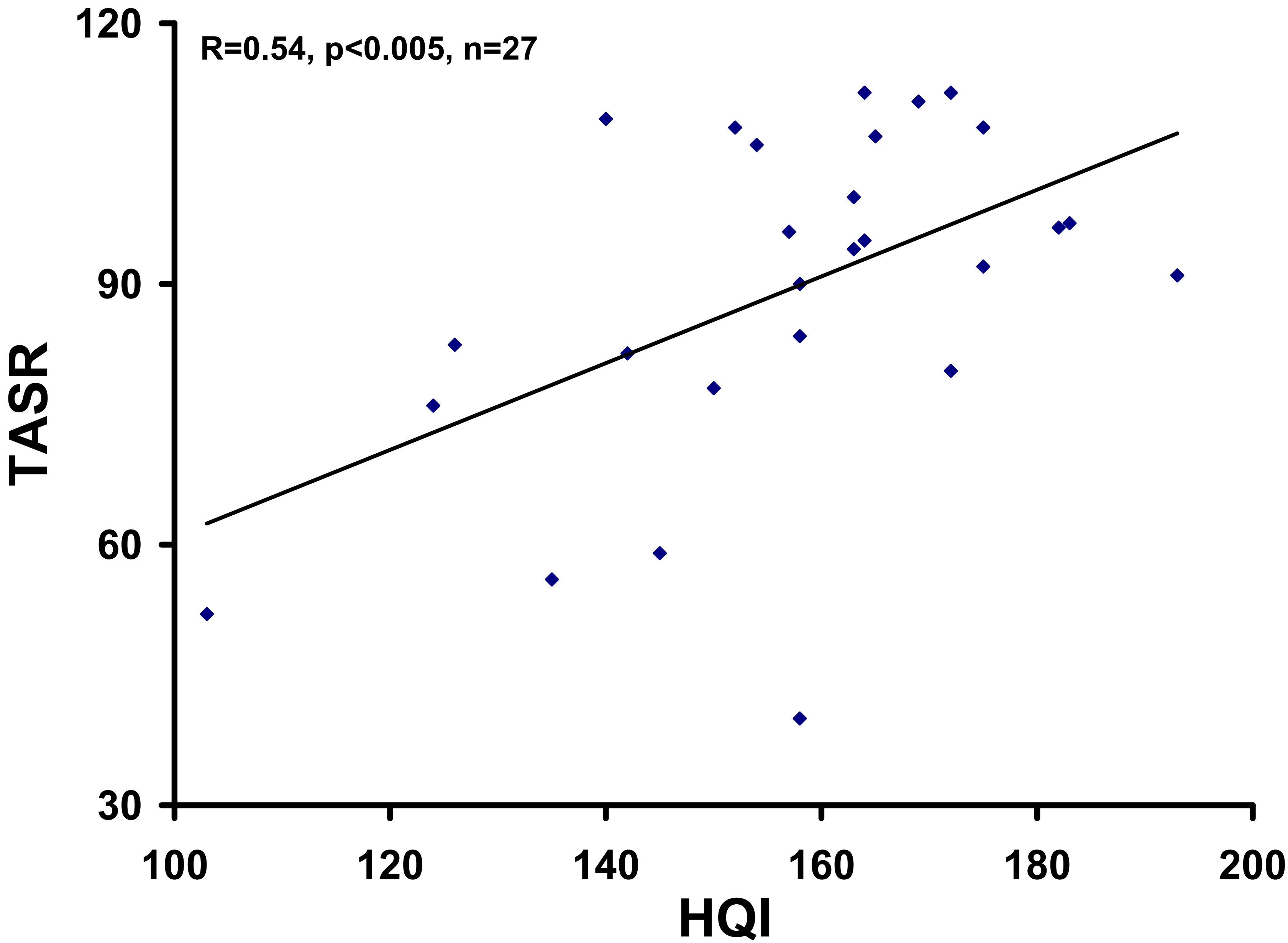

Figure 15. Correlation between total aquatic species richness (TASR) and Habitat Quality Index (HQI, Barbour et al. 1999) for streams characterized by varied riparian and channel properties. Correlations were considered significant at α=0.005.

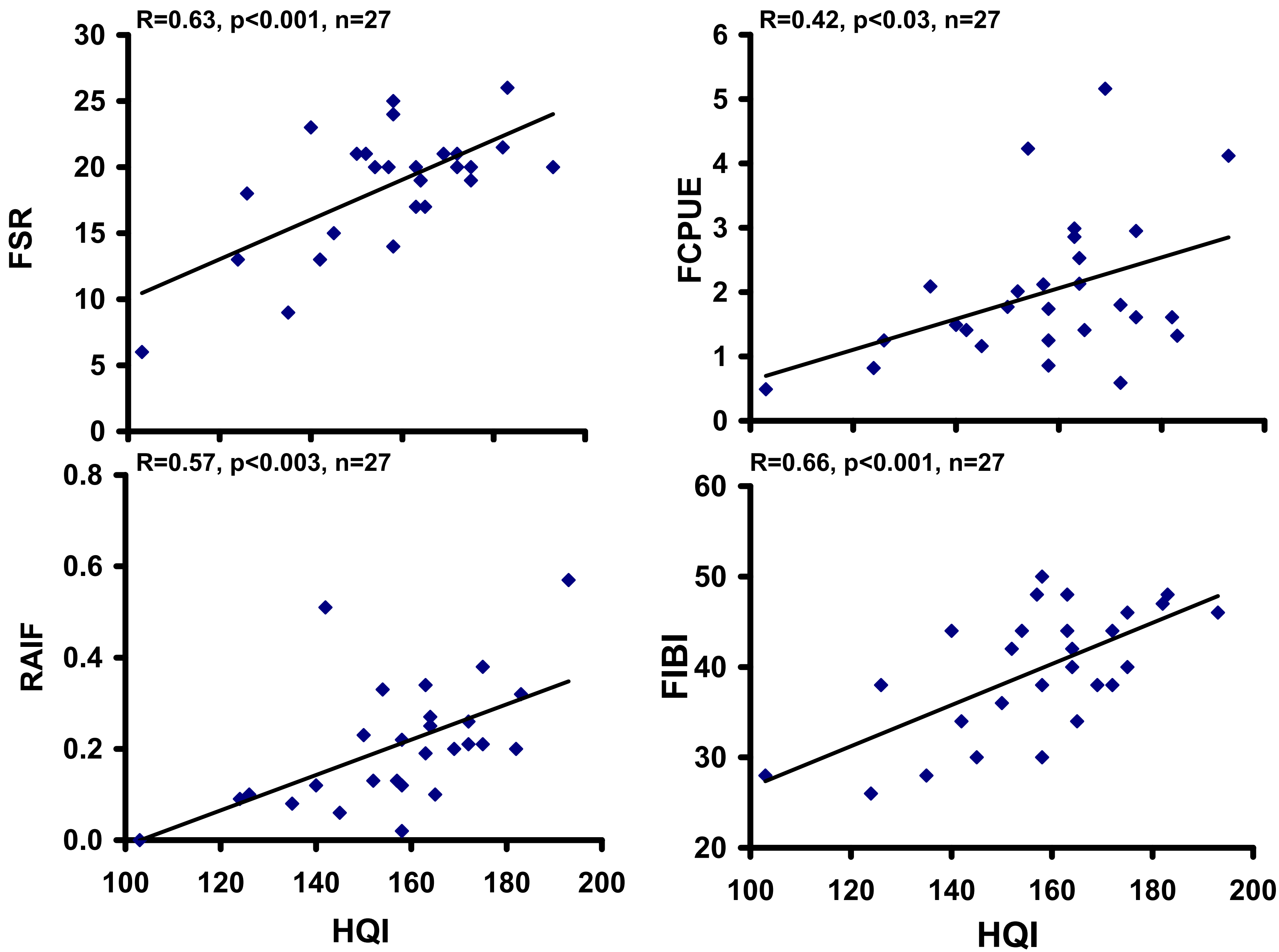

Figure 16. Correlations between fish community measures, including fish species richness (FSR), fish catch per unit effort (FCPUE), relative abundance of intolerant fish (RAIF) and fish index of biotic integrity (FIBI), and habitat quality index (HQI) values for streams characterized by varied riparian and channel properties. Correlations were considered significant at α=0.005.

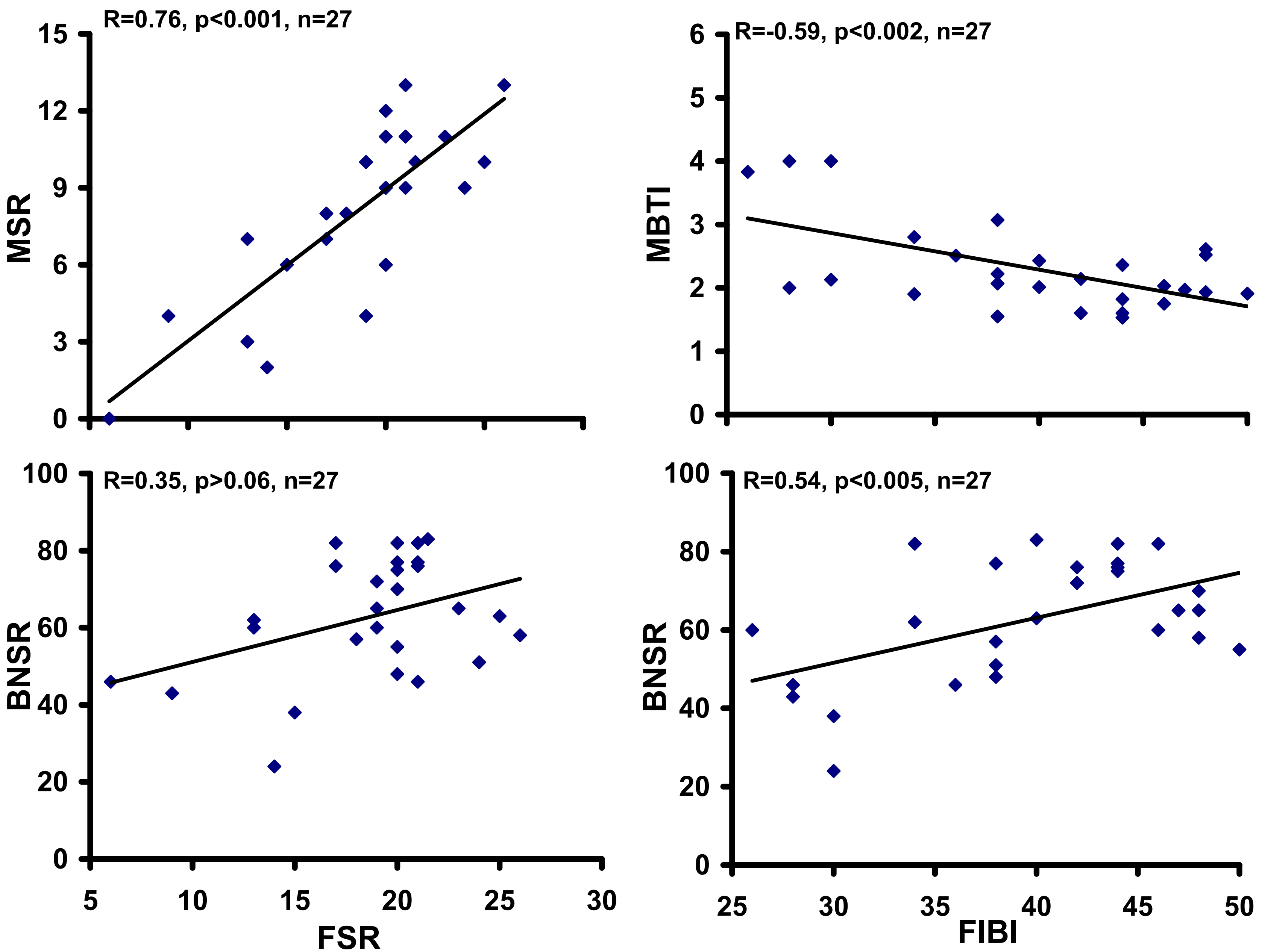

Figure 17. Correlations between fish species richness (FSR), mussel species richness (MSR) and benthic species richness (BNSR), and fish index of biotic integrity (FIBI) measures, musel biological tolerance index (MBTI) and BNSR for streams characterized by varied riparian and channel properties. Correlations were considered significant at α=0.005.

Table 5. Floristic and ecological variables measured at riparian study sites, including total number of plant species (TSP), total number of native plant species (TNPS), total number of adventive plant species (TAPS), percent of all species as native species (%Native), percent of all species as adventive species (%Adventive), Floristic Quality Index (FQI), Coefficient of Conservatism (COC), number of ecological zones (#Zones) and coefficient of topographic variation (CTV). River basins include the Grand, (GR), Kalamazoo (KZ), Raisin (RR), St. Joseph (SJ), Pine (PR), Shiawassee (SH), Looking Glass (LG), Red Cedar (RC), Maple (MR), and Thornapple (TR) Rivers and Sycamore Creek (SC). Riparian forest buffer width classed include <125m, 125-250m and 250-500m.

SITE	TPS	TNPS	TAPS	%Native	%Adventive	FQI	Mean COC	#Zones	CTV
GR <125	87	83	4	0.95	0.05	36.5	3.9	1.00	-0.65
GR 125-250	90	80	10	0.89	0.11	33.3	3.5	4.00	0.72
GR 250-500	161	151	10	0.94	0.06	49.6	3.9	4.00	0.23
KZ<125	137	124	13	0.91	0.09	40.5	3.5	2.00	0.27
KZ125-250	149	128	21	0.86	0.14	38.0	3.1	2.00	0.31
KZ250-500	166	159	7	0.96	0.04	50.8	3.9	3.00	-0.08
RR<125	92	84	8	0.91	0.09	35.7	3.7	3.00	0.32
RR125-250	107	99	8	0.93	0.07	38.5	3.7	2.00	0.38
RR250-500	154	143	11	0.93	0.07	48.4	3.9	4.00	0.51
SJ<125	73	68	5	0.93	0.07	31.1	3.6	1.00	-0.27
SJ125-250	137	131	6	0.96	0.04	49.7	4.2	3.00	-0.25
SJ250-500	97	90	7	0.93	0.07	38.1	3.9	2.00	-0.11
PR<125	122	107	15	0.88	0.12	39.70	3.60	2.00	0.27
PR125-250	161	154	7	0.96	0.04	47.8	3.8	2.00	-0.12
PR250-500	158	149	9	0.94	0.06	47.3	3.8	2.00	0.23
SH<125	133	123	10	0.92	0.08	45.1	3.9	2.00	0.21
SH125-250	148	129	19	0.87	0.13	44.6	3.4	2.00	0.19
SH250-500	224	199	25	0.89	0.11	54.9	3.7	2.00	0.21
LG<125	155	141	14	0.91	0.09	46	3.7	3.00	0.66
LG125-250	165	148	17	0.9	0.1	45.7	3.6	3.00	0.35
RC<125	95	79	16	0.83	0.17	32.7	3.4	1.00	0.15
RC125-250	177	164	13	0.93	0.07	52.8	4	3.00	0.34
SC250-500	143	133	10	0.93	0.07	46.5	3.9	2.00	0.22
MR<125	87	76	11	0.87	0.13	26.7	2.9	1.00	0.12
MR125-250	101	92	9	0.91	0.09	35.3	3.5	3.00	0.22
MR250-500	186	175	11	0.94	0.06	53.7	3.9	3.00	-0.08
TR125-250	156	144	12	0.92	0.08	50.9	4.1	2.00	0.37

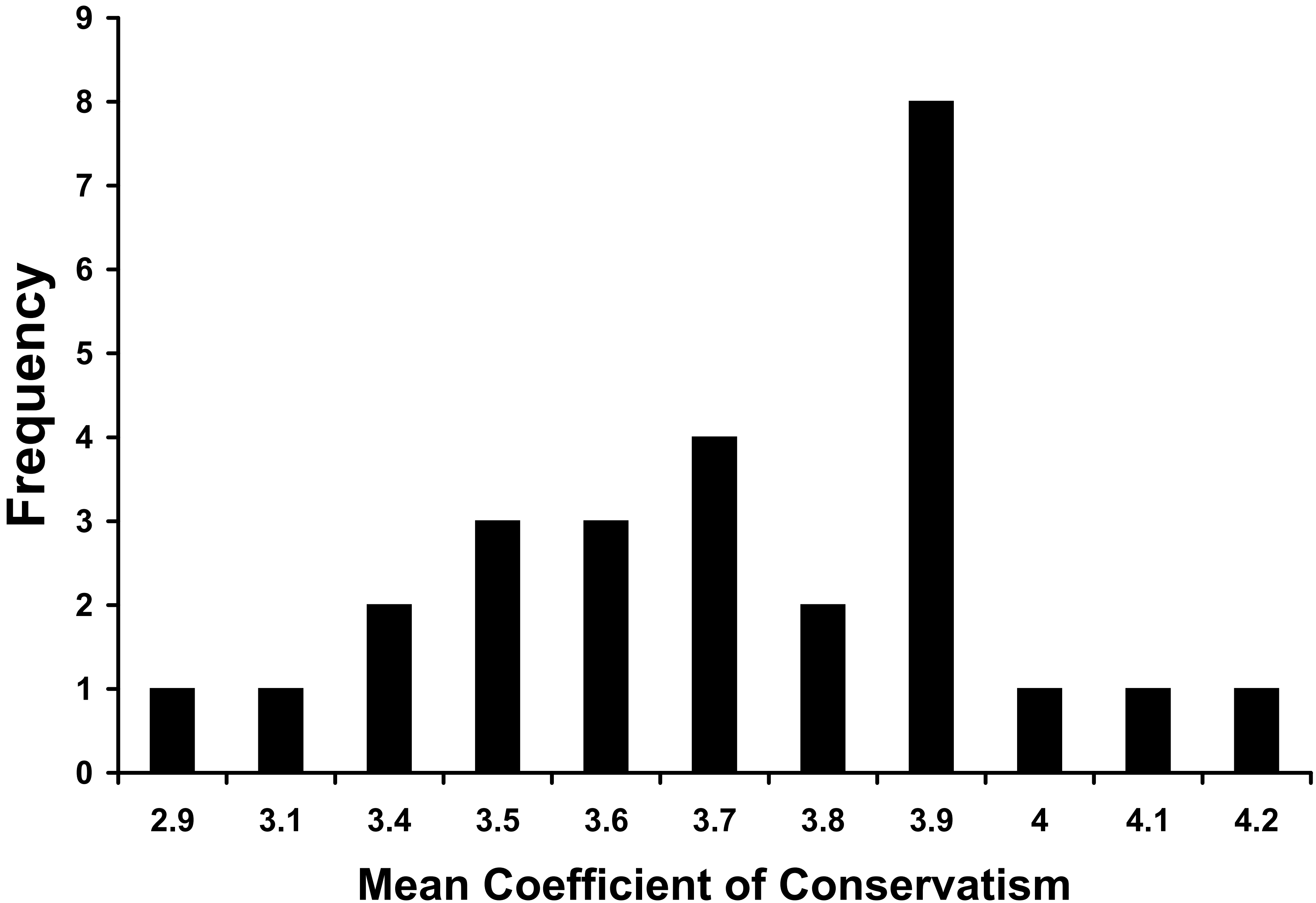

Figure 18. Frequency of mean coefficient of conservatism values among 27 riparian areas of watersheds in southern Lower Michigan surveyed during 2000 and 2001.

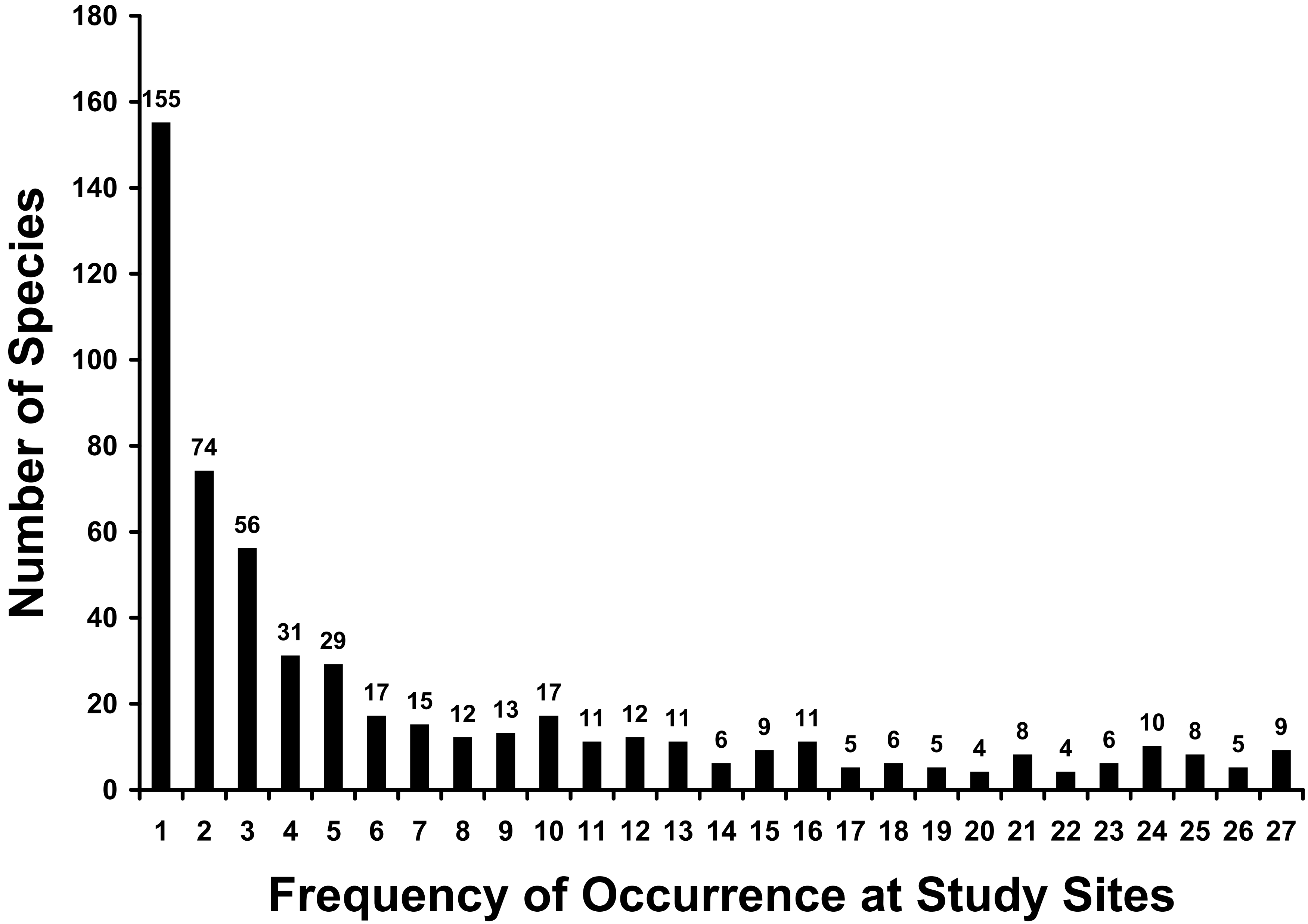

Figure 19. Plant species frequency of occurrence at riparian study sites (e.g., 155 species occurred at only one site, 74 species occurred at two sites, 56 species occurred at three sites, etc.)

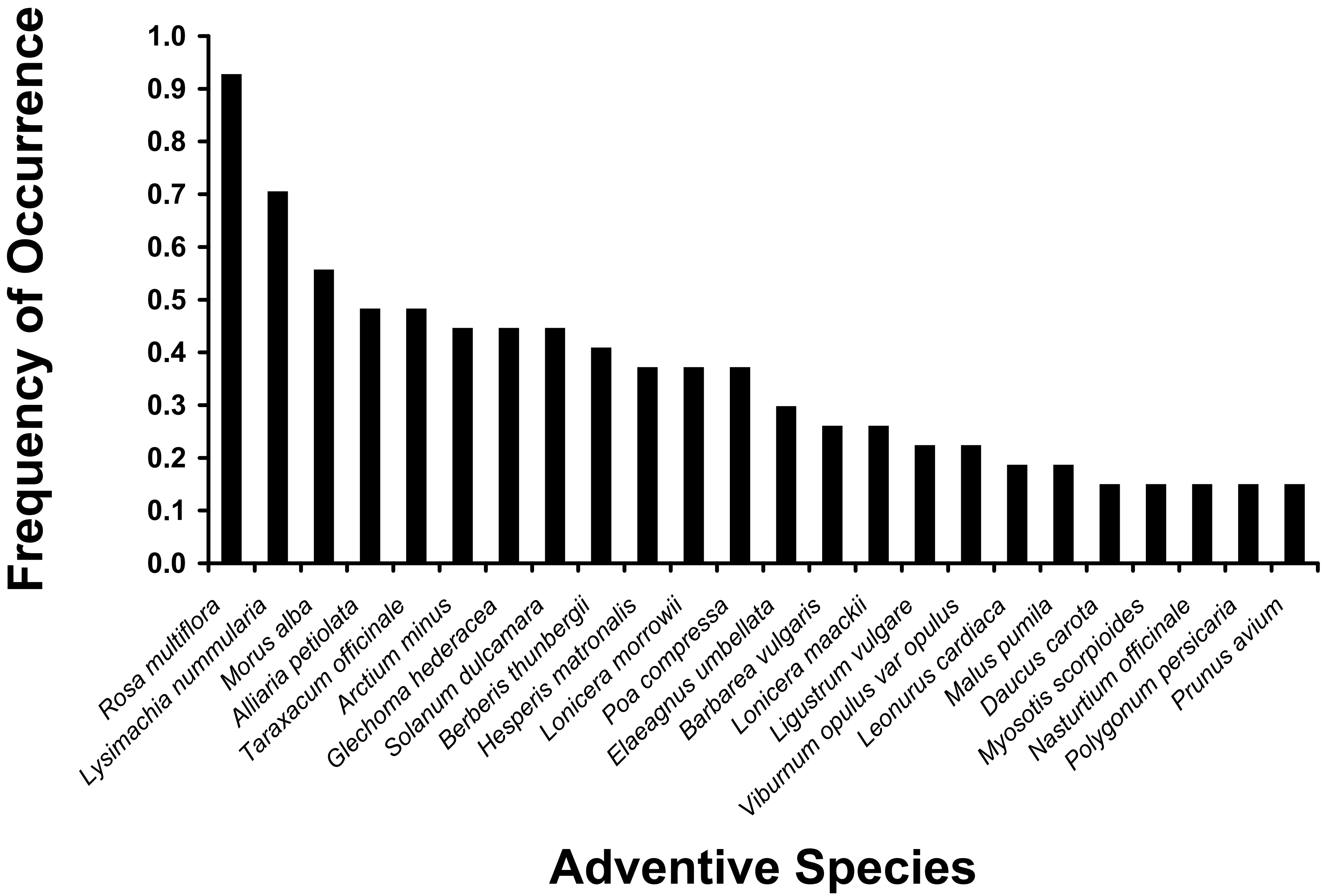

Figure 20. Frequency of occurrence (proportion of all study sites) for the 24 most prevalent adventive species observed in riparian survey areas.

occurrence of prairie fen and 11 occurrences of southern floodplain forest were identified from twelve sites. Prairie fen is a globally and state rare community (G3/ S3) known from 112 sites in Michigan. Southern floodplain forest is currently classified as G3?/S3, indicating that it is tentatively considered globally rare and rare within the state; high quality floodplain forests are tracked at approximately 40 sites in Michigan.

Four state-listed as threatened species, including *Diarrhena americana* (American beak grass), *Fraxinus profunda* (pumpkin ash), *Morus rubra* (red mulberry), and *Trillium nivale* (snow trillium), and seven special concern species, including *Carex davisii* (Davis' sedge), *Carex frankii* (Frank's sedge), *Carex squarrosa* (a sedge), *Carex trichocarpa* (a sedge), *Euonymus atropurpurea* (wahoo), *Gymnocladus dioicus* (Kentucky coffee-tree), and *Lithospermum latifolium* (broad-leaved puccoon), were identified over a total of 14 sites. These species are all restricted to southern Lower Michigan where they reach the northernmost edges of their respective ranges.

Several of these species are extremely rare in Michigan. *Trillium nivale* and *Fraxinus profunda* are known from fewer than 10 sites, and *Diarrhena americana, Carex squarrosa, C. trichocarpa,* and *Morus rubra* are known from fewer than 20 sites. The majority of the rare species observed comprise taxa found almost exclusively in floodplain forests in Michigan, although within their main ranges to the south they may occur in markedly different habitats, including mesic to even dry-mesic upland forests.

Two study sites were particularly rich in rare species, accounting for nearly 50% of the total occurrences observed. The SH250-500A site contained occurrences of five rare species (*Diarrhena americana*, *Euonymus atropurpurea*, *Gymnocladus dioicus*, *Lithospermum latifolium*, and *Trillium nivale*), the most observed during the study. This site was also the highest in total floristic richness (Table 5). The RC125-250 site contained four rare species occurrences (*Carex davisii*, *Carex frankii*, *Diarrhena americana*, and *Euonymus atropurpurea*), and reflected the third highest site in floristic richness.

Adventive Plant Species

A total of 68 adventive (non-native or exotic) species was identified from 27 sites, representing 12.5% of the 544 vascular plants documented during the study. Of the 68 adventives, 10 were tree species, 11 were shrub species, 21 were perennial forb species, 7 were biennial forb species, 7 were annual forb species, 9 were perennial grass species, and 3 were annual grass species. The vast majority of adventive species were observed in fewer than 50% of the study sites, and only three species were found at more than 50% of the sites. *Rosa multiflora* (multiflora rose) was the most frequently observed, occurring at 25 sites (Figure 20). *Lysimachia nummularia* (moneywort) occurred at 19 sites, and *Morus alba* (white mulberry) occurred at 15 sites. Additional species occurring relatively frequently included *Alliaria petiolata* (garlic mustard), *Taraxacum officinale* (dandelion), *Arctium minus* (burdock), *Glechoma hederacea* (gill-over-the-ground), *Solanum dulcamara* (bittersweet nightshade), and *Berberis thunbergii* (Japanese barberry).

Frequency of occurrence was not necessarily an indicator of invasiveness at riparian sites. For example, *Taraxacum officinale* occurred frequently. However, this ubiquitous weed species occurred primarily as a function of edge disturbance where it was not competitive or observed to be displacing native riparian vegetation. Similar such species included *Arctium minus*, *Poa compressa* (bluegrass), *Barbarea vulgaris* (smooth rocket), *Leonurus cardiaca* (motherwort), *Malus pumila* (common apple), *Daucus carota* (Queen Anne's lace), and *Myosotis scirpoides* (forget-me-not). The most pernicious and invasive adventives observed were *Alliaria petiolata* (garlic mustard), *Elaeagnus umbellate* (Autumn olive), *Glechoma hederacea*, *Lysimachia nummularia*, *Hesperis matronalis* (dame's rocket), several honeysuckle species (*Lonicera morrowii, L. Xbella, L. maackii, L. tartarica*), *Lythrum salicaria* (purple loosestrife), *Rhamnus cathartica* (buckthorn), *R. frangula* (glossy leaved buckthorn), and, to some extent, *Morus alba*, *Berberis thunbergii*, *Ligustrum vulgare*, and *Viburnum opulus* var. *opulus* (European highbush cranberry). Occasionally, invasive species were found in association with local disturbances within floodplain forests. For example, a large *Ailanthus altissima* (tree-of-heaven), and a small grove of *Catalpa speciosa (*Northern catalpa), were each found in disturbance openings where they have the potential to compete and become more widespread. These species were found in only one or two sites.

Vegetation and Floristic Parameters

Site-specific means for plot data (Table 6) were calculated for BA, NTS, DBH, USSt, USSp, GCS and %GC. The number of zones per site, site coefficient of topographic variation (CTV), total number of plant species per site (TPS), total number of native plant species per site (TNPS), total number of adventive plant species per site (TAPS), percent native species per site, percent adventive species per site, site FQI, and site $\overline{C}$ are given in Table 5.

Vegetation and Floristic Responses to Varied Riparian Forest Buffer Width Classes

Means for sample plot data were calculated for sites and by riparian forest buffer width class for BA, NTS, DBH, USSt, USSp, GCS, %GC (Tables 7 and 8, Figures 21-24). ANOVAs with riparian buffer width class and channel type as fixed factors and BA as the dependent variable indicated an interaction between riparian class and channel type ($F=3.6$, $p<0.02$). Thus, separate ANOVAs segregated by channel type were conducted. For channel type B, mean BA for 250-500m sites ($\bar{x}$=32.6 m^2/hectare) was higher than mean BA for <125m sites ($\bar{x}$=27.7 m^2/hectare) and 125-250m sites ($\bar{x}$=24.2 m^2/hectare) ($F=10.5$, $p<0.011$). ANOVAs for the remaining plot data parameters indicated no significant differences in these variables among riparian forest buffer width classes, including NTS ($F=1.7$, $p>0.20$), DBH ($F=1.6$, $p>0.20$), USSt ($F=1.0$, $p>0.23$), USSp ($F=0.1$, $p>0.9$), GCS ($F=1.9$, $p>0.15$), %GC ($F=1.2$, $p>0.30$) and CTV ($F=1.4$, $p>0.25$).

For the floristic data, ANOVAs with riparian buffer width class and channel type as fixed factors were conducted for TPS, TNPS, TAPS, FQI and $\overline{C}$ as the dependent variables. No interaction between riparian buffer width class and channel type was indicated for these ANOVAs. TPS, TNPS, and FQI were significantly different among the riparian buffer width classes (Table 7 and Figures 25, 26 and 27). Post hoc (LSD) tests indicated that the mean TPS for the 250-500m buffer width class ($\bar{x}$=161.1±12.7 plant species) was significantly higher than the mean for the <125m buffer width class ($\bar{x}$=109.0±9.4 plant species) ($F=5.7$, $p<0.012$). There was no significant difference between the mean TPS for the <125m and 125-250m buffer width classes, nor between 125-250m and 250-500m buffer width classes, although the post hoc test for the latter ($p<0.06$) was nearly significant. Mean TNPS for the 250-500m riparian buffer width class ($\bar{x}$=149.9±11.2 plant species) was significantly higher than the mean for the <125m buffer width class ($\bar{x}$=98.3±8.7 palnt species) ($F=6.7$, $p<0.007$). Mean TNPS values also showed a marginally significant difference between the <125m and 125-250m riparian buffer width classes ($p=0.05$), providing additional evidence to suggest that lower plant diversity occurs within narrow riparian corridors compared to wider, more contiguous corridors. Mean FQI was significantly higher for the 250-500m ($\bar{x}$=48.7±1.8) and 125-250m ($\bar{x}$=43.7±2.2) buffer width classes compared to the <125m buffer width class ($\bar{x}$=37.1±2.1) ($F=6.7$, $p<0.007$). Mean TAPS ($F=1.18$, $p>0.08$) and $\overline{C}$ ($F=2.335$, $p>0.12$) were not significantly different among the riparian buffer width classes (Table 7 and Figures 25 and 26).

Vegetation and Floristic Responses to Varied Channel Types

Means for sample plot data were calculated for sites and by channel type for BA, NTS, DBH, USSt, USSp, GCS, %GC and CTV (Table 9 and Figures 21-24). In addition, means were calculated for floristic characteristic based on the different channel types, including TPSS, TAPS, FQI, and ($\overline{C}$) (Table 7 and Figures 25, 26 and 27). Mean NTS values were nearly significantly greater for channel type B ($\bar{x}$=4.5± 0.4 species/plot) compared to channel type C ($\bar{x}$=3.4± 0.1 species/plot, $F=3.2$, $p<0.07$) (Figure21). Within the understory layer, there was a trend towards higher mean USSp for channel type A ($\bar{x}$=6.4± 0.8 species/plot) compared channel types B and C ($\bar{x}$=4.4± 0.6 and $\bar{x}$=4.3± 0.4 species/plot, respectively, Figure 23), although this was not a statistically significant trend ($F=2.2$, $p>0.13$). Mean GCS was highest for channel type A ($F=5.8$, $p<0.01$) compared to both channel types B and C (Figure 24). ANOVAs for BA indicated a significant interaction between channel type and riparian buffer width class ($F=3.6$, $p<0.02$) (Figure 21). Mean BA for channel type A in the 125-250m buffer width class ($\bar{x}$=26.4± 0.9 m^2/ha) was higher than mean BA for channel type C in the 125-250m buffer width class ($\bar{x}$=22.2± 1.2 m^2/ha) ($F=5.9$, $p<0.03$). In addition, for the 250-500m buffer width class, mean BA for channel type B ($\bar{x}$=32.6± 1.6 m^2/ha) was higher than mean BA for channel types A ($\bar{x}$=25.7± 1.7 m^2/ha) and C ($\bar{x}$=25.4±0.8 m^2/ha) ($F=6.6$, $p<0.04$). Mean DBH ($F=0.15$, $p>0.86$), USSt ($F=1.5$, $p>0.24$), %GCS ($F=1.7$, $p>0.22$) and CTV ($F=1.8$, $P>0.19$) were not significantly different among the channel types (Figures 22, 23, 24 and 28).

ANOVAs for the floristic parameters measured indicated no significant interactions between channel type and buffer width class for these analyses. The results of these analyses indicated that there were also no significant differences in mean TPS ($F=1.45$, $p>0.25$), TNPS ($F=1.71$, $p>0.32$), TAPS ($F=2.39$, $p>0.10$), FQI ($F=0.50$, $p>0.60$), and $\overline{C}$ ($F=0.53$, $p>0.60$) among channel types characteristic of the riparian areas samped (Table 7 and Figures 25, 26 and 27).

Table 6. Weighted means for ecological variables measured at 27 riparian forest sites. River basins sampled include the Grand, (GR), Kalamazoo (KZ), Raisin (RR), St. Joseph (SJ), Pine (PR), Shiawassee (SH), Looking Glass (LG), Red Cedar (RC), Maple (MR), and Thornapple (TR) Rivers and Sycamore Creek (SC). Riparian forest buffer width classes include <125m, 125-250m and 250-500m.

SITE	Basal Area (m^2/hectare) MEAN	#Tree Species/Plot MEAN	DBH cm By Prism Plot MEAN	# Woody Stems/Plot MEAN	# Understory Species/Plot MEAN	# Ground Cover Species/Plot MEAN	% Ground Cover/Plot MEAN
GR <125	**18.0**	**3.2**	**38.5**	**4.2**	**1.6**	**8.6**	**56.8**
GR 125-250	**23.2**	**2.9**	**27.3**	**9.1**	**3.2**	**4.8**	**22.7**
GR 250-500	**24.5**	**3.8**	**29.6**	**37.5**	**6.8**	**7.0**	**19.3**
KZ<125	**17.3**	**2.7**	**38.4**	**51.4**	**8.4**	**8.5**	**64.7**
KZ125-250	**24.0**	**3.9**	**29.6**	**19.0**	**7.2**	**8.8**	**48.6**
KZ250-500	**26.8**	**4.7**	**29.3**	**26.9**	**5.5**	**10.6**	**34.8**
RR<125	**22.3**	**3.9**	**47.1**	**37.2**	**6.0**	**6.6**	**55.3**
RR125-250	**28.2**	**3.6**	**54.0**	**19.7**	**5.4**	**5.6**	**42.1**
RR250-500	**28.0**	**4.3**	**30.6**	**27.1**	**7.0**	**7.7**	**32.0**
SJ<125	**24.8**	**3.6**	**45.4**	**5.6**	**1.4**	**1.6**	**12.6**
SJ125-250	**24.1**	**4.9**	**45.1**	**29.9**	**6.0**	**7.4**	**22.0**
SJ250-500	**30.6**	**3.2**	**53.4**	**9.1**	**3.0**	**3.2**	**20.1**
PR<125	**25.5**	**4.4**	**37.0**	**66.6**	**11.8**	**6.9**	**36.3**
PR125-250	**24.3**	**3.1**	**23.8**	**13.1**	**3.6**	**8.7**	**27.3**
PR250-500	**31.3**	**6.0**	**30.0**	**31.2**	**7.0**	**8.4**	**15.4**
SH<125	**30.2**	**5.2**	**28.4**	**28.4**	**4.0**	**3.7**	**9.6**
SH125-250	**26.9**	**4.3**	**28.3**	**28.2**	**6.8**	**8.4**	**38.8**
SH250-500	**22.4**	**3.5**	**32.4**	**31.3**	**4.5**	**6.6**	**70.8**
LG<125	**25.3**	**3.4**	**38.1**	**23.7**	**3.5**	**4.2**	**26.7**
LG125-250	**26.6**	**2.2**	**35.9**	**29.7**	**5.9**	**9.0**	**77.1**
CR<125	**28.0**	**5.4**	**48.5**	**33.6**	**6.0**	**5.4**	**87.6**
CR125-250	**23.6**	**3.3**	**34.2**	**18.3**	**4.6**	**5.7**	**47.9**
SC250-500	**35.8**	**5.4**	**33.6**	**12.9**	**4.7**	**6.1**	**26.7**
MR<125	**34.0**	**3.6**	**44.1**	**1.4**	**0.8**	**3.2**	**74.2**
MR125-250	**24.1**	**3.4**	**27.0**	**15.1**	**3.8**	**4.6**	**58.6**
MR250-500	**26.2**	**3.6**	**43.2**	**28.3**	**3.5**	**4.7**	**34.0**
TR125-250	**19.8**	**3.2**	**33.5**	**12.3**	**5.7**	**8.3**	**62.3**

Table 7. Summary of floristic parameters by buffer width class and channel type. Parameters include the total number of plant species/site (TPS), total number of native plant species (TNPS), total number of adventive plant species (TAPS), Floristic Quality Index (FQI), and Coefficient of Conservatism (COC).

		TPS		TNPS		TAPS		FQI		COC	
Buffer Width	**Channel Type**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**
<125m	All	109.0	9.4	98.3	8.7	10.7	1.4	37.1	2.1	3.7	0.1
	A	115.3	14.8	104.6	11.9	10.7	3.4	38.9	1.2	3.7	0.1
	B	100.3	17.5	90.0	16.8	10.3	3.2	36.3	4.4	3.6	0.1
	C	111.3	21.9	100.3	20.4	11.0	1.7	36.1	5.6	3.4	0.3
125-250m	All	139.1	9.4	126.9	8.9	12.2	1.7	43.7	2.2	3.7	0.1
	A	142.2	12.4	126.0	10.1	16.2	2.8	41.7	2.0	3.4	0.1
	B	133.0	17.4	125.7	18.1	7.3	0.9	44.2	4.5	3.8	0.2
	C	141.0	26.2	129.3	25.3	11.6	0.9	45.6	6.2	3.9	0.2
250-500m	All	161.1	12.7	149.9	11.2	11.2	2.0	48.7	1.8	3.9	0.1
	A	181.3	21.6	167.0	16.7	14.3	5.4	51.4	1.9	3.8	0.1
	B	132.7	18.3	124.0	17.6	8.7	0.9	44.0	2.9	3.9	0.1
	C	173.5	12.5	163.0	12.0	10.5	0.5	51.7	2.0	3.9	0.0

Table 8. Summary of vegetation measures by buffer width class and channel type. Parameters include basal area, number of tree species/plot (NTS), diameter at breast height by prism plot (DBH), number of woody stems/plot (USSt), number of understory species/plot (USSp), number of ground cover species/plot (GCS) and the percentage of ground cover/plot (%GC).

		Basal Area		NTS		DBH		USSt		USSp		GCS		%GCS	
Buffer Width	**Channel Type**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**
<125m	All	25.0	1.8	3.9	0.3	40.6	2.1	28.0	7.4	4.8	1.2	5.4	0.8	47.1	9.1
	A	20.3	2.6	3.4	0.5	38.0	0.5	40.7	18.8	7.2	3.0	8.0	0.6	52.6	8.7
	B	27.7	1.6	4.7	0.6	40.7	6.2	22.5	8.6	3.8	1.3	3.6	1.1	36.6	25.5
	C	27.2	3.5	3.6	0.1	43.1	2.7	20.7	10.4	3.4	1.5	4.7	1.0	52.1	13.8
125-250m	All	24.5	0.7	3.5	0.2	33.9	2.9	19.5	2.4	5.2	0.4	7.1	0.6	44.7	5.7
	A	26.4	0.9	3.5	0.5	36.9	5.9	24.2	2.8	6.3	0.4	8.0	0.8	51.6	8.7
	B	24.2	0.1	3.8	0.6	32.0	6.6	19.4	5.3	4.5	0.8	6.9	1.2	35.9	11.4
	C	22.2	1.2	3.1	0.1	31.7	2.2	13.3	2.7	4.5	0.7	6.3	1.1	44.3	11.6
250-500m	All	28.2	1.5	4.3	0.3	35.3	3.0	25.5	3.4	5.3	0.6	6.8	0.8	31.6	6.2
	A	25.7	1.7	4.2	0.4	30.8	0.9	28.4	1.5	5.7	0.7	8.3	1.2	45.9	12.5
	B	32.6	1.6	4.9	0.8	39.0	7.3	17.7	6.8	4.9	1.2	5.9	1.5	20.8	3.3
	C	25.4	0.8	3.7	0.1	36.4	6.8	32.9	4.6	5.2	1.7	5.9	1.1	26.6	7.3

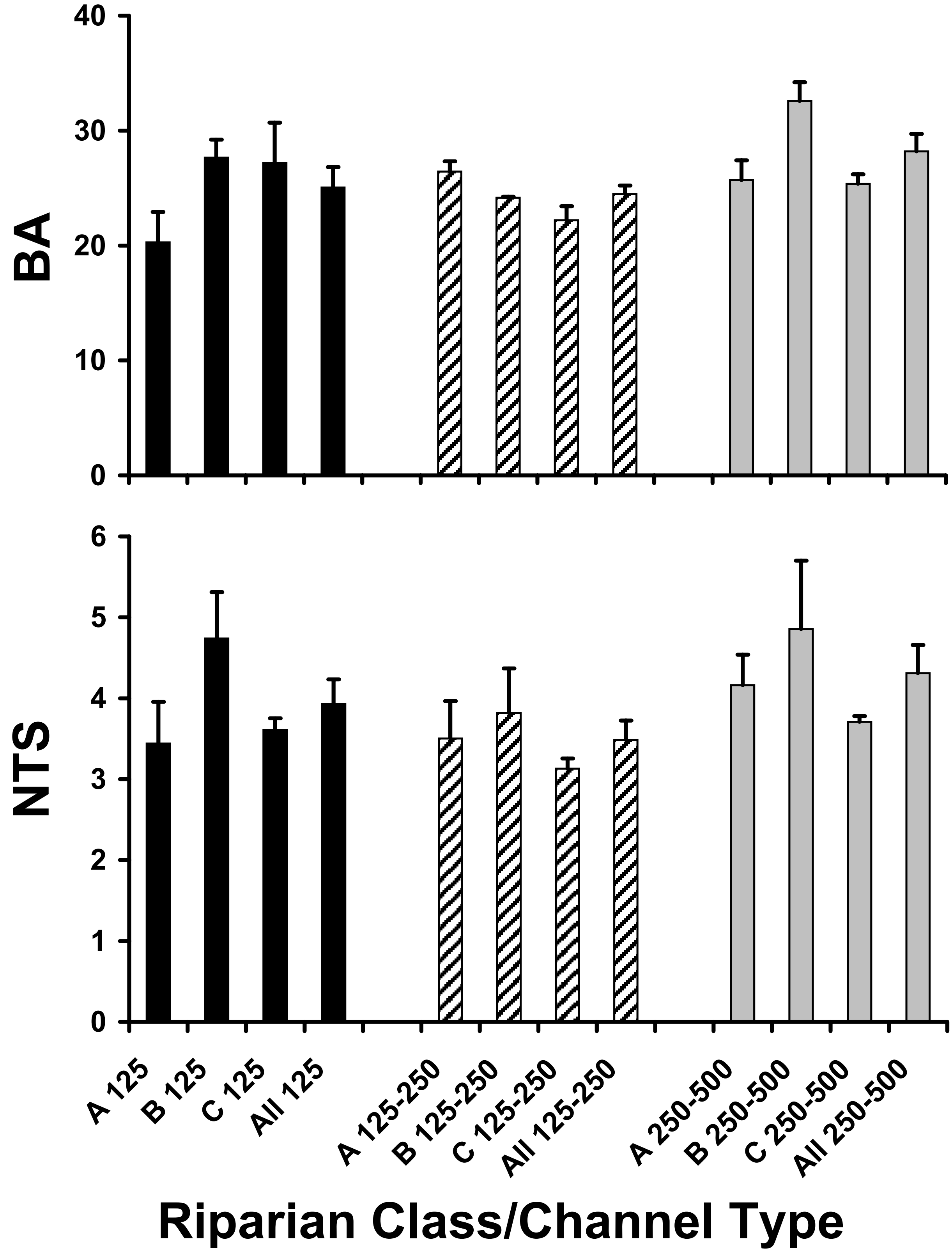

Figure 21. Basal area (BA, m^2/ha) and number of tree species (NTS) from 10-factor prism plots (mean +1 SE) by channel type (A, B, and C) and grouped by buffer width class (<125m black, 125-250m striped, 250-500m gray).

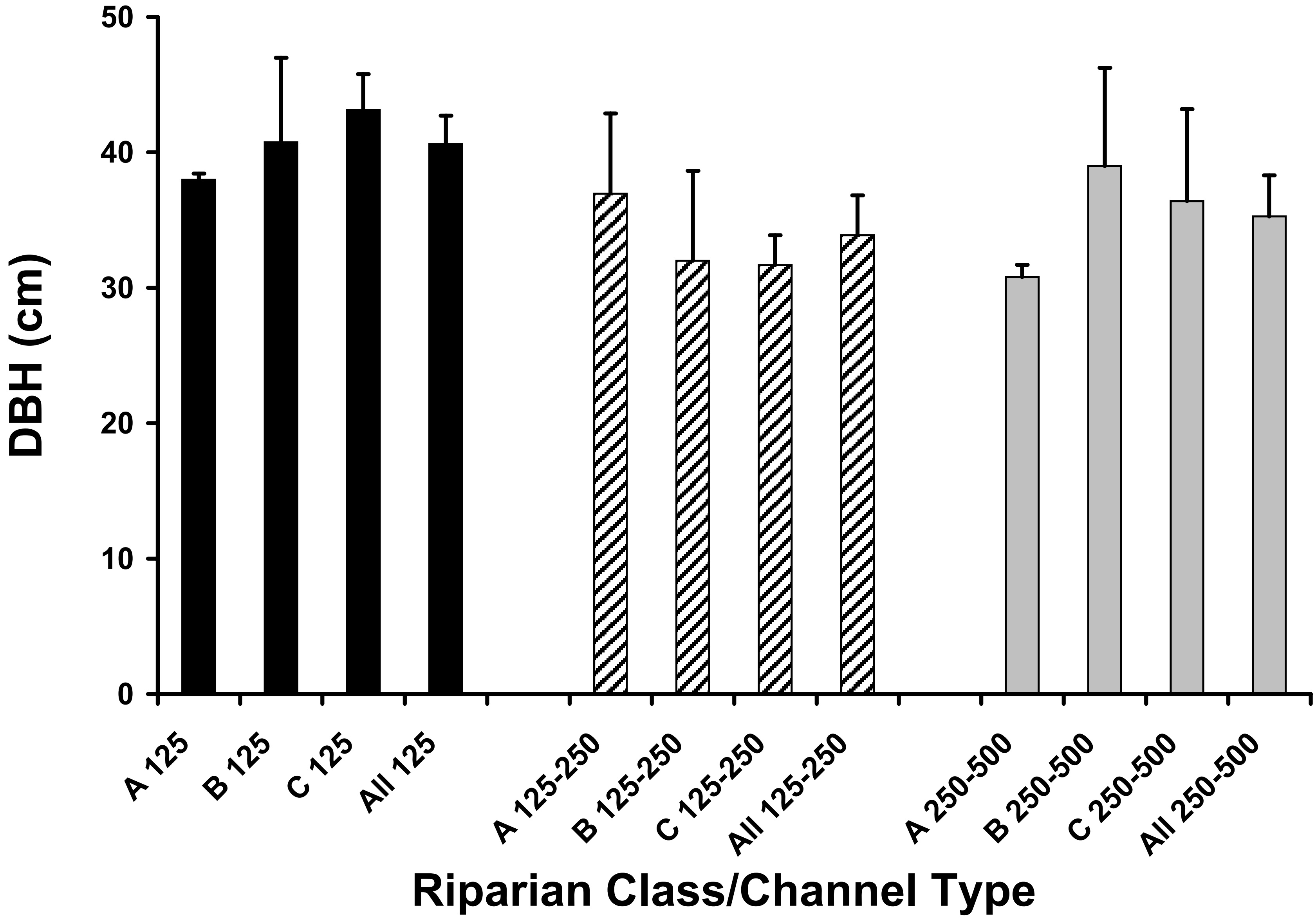

Figure 22. Mean (+1 SE) tree diameter at breast height (DBH) measures from 10-factor prism plots according to channel type (A, B, and C) and grouped by buffer width class (<125m black, 125-250m striped, 250-500m gray).

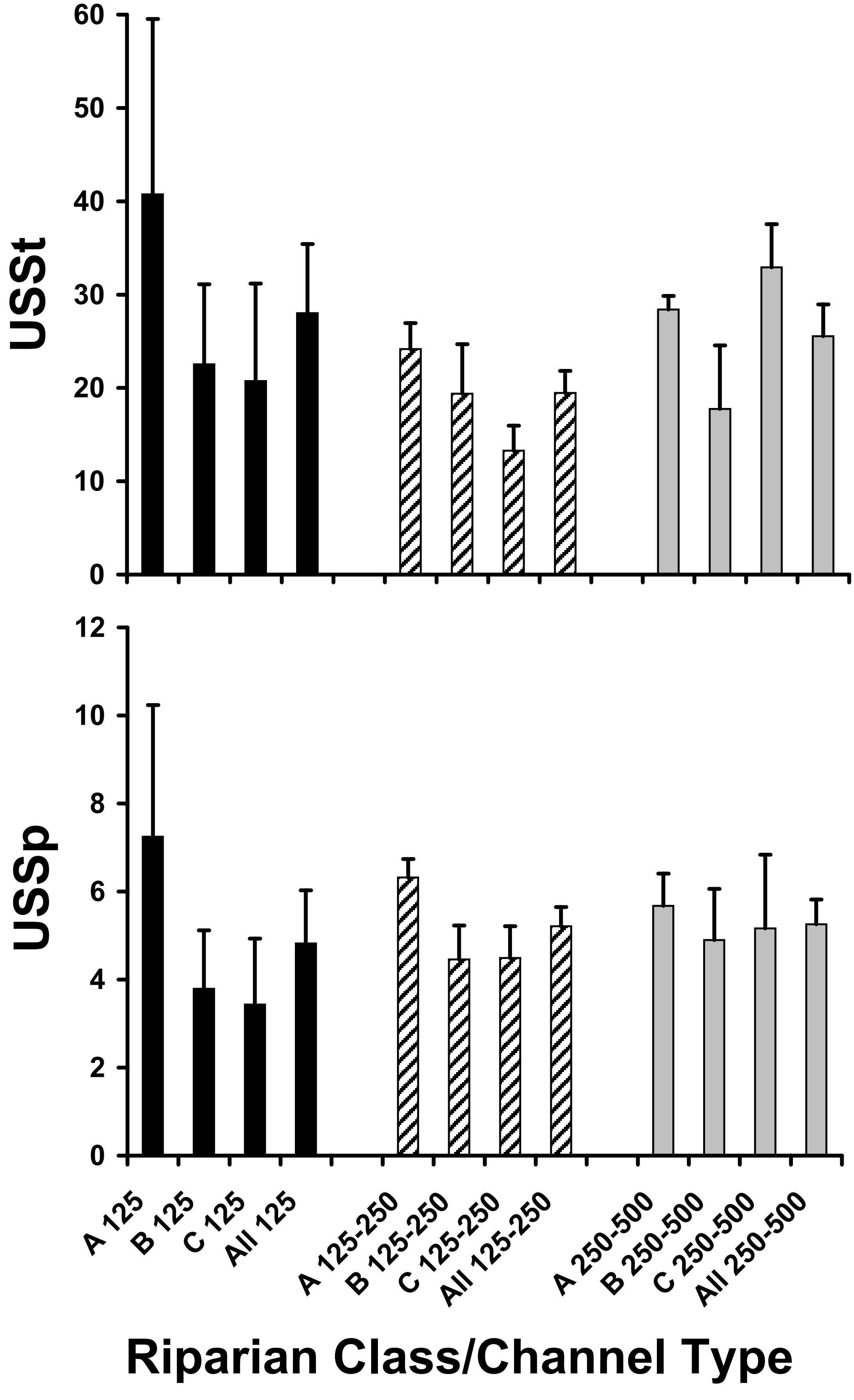

Figure 23. Mean (+1 SE) number of understory stems (USSt) and understory speciues (USSp) for 5-m radius understory plots by channel type (A, B and C) and grouped by buffer width class (<125m black, 125-250m striped, 250-500m gray).

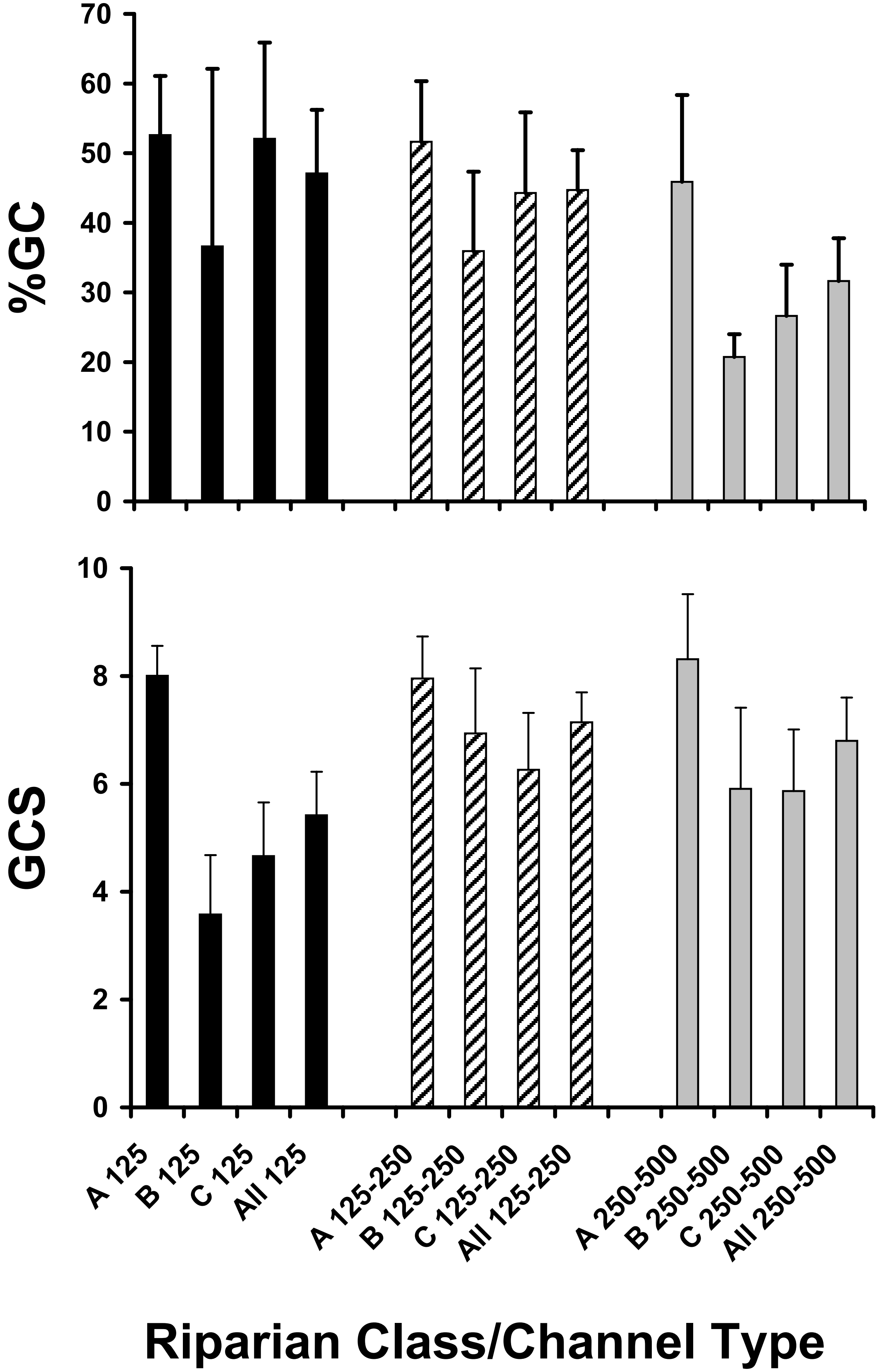

Figure 24. Mean (+1 SE) percent ground cover (%GC) and number of ground cover species (GCS) from 1-m^2 ground cover plots at riparian study sites according to channel type (A, B and C) and grouped by buffer width class (<125m black, 125-250m striped, 250-500m gray).

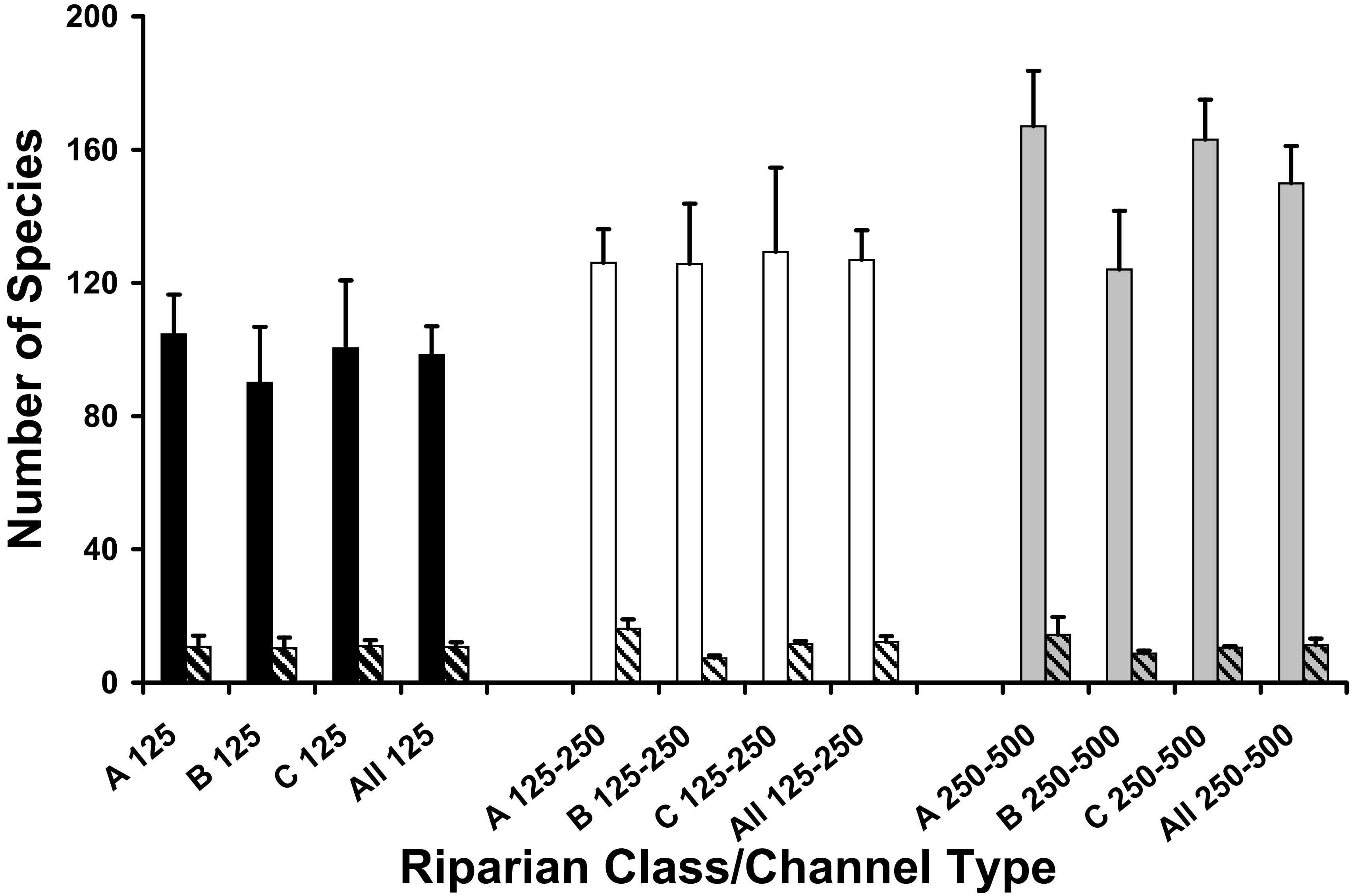

Figure 25. Mean number of native species (solid) and adventive species (striped) (+1 SE) according to channel type (A, B and C) and grouped by buffer width class (<125m black, 125-250m white, 250-500m gray).

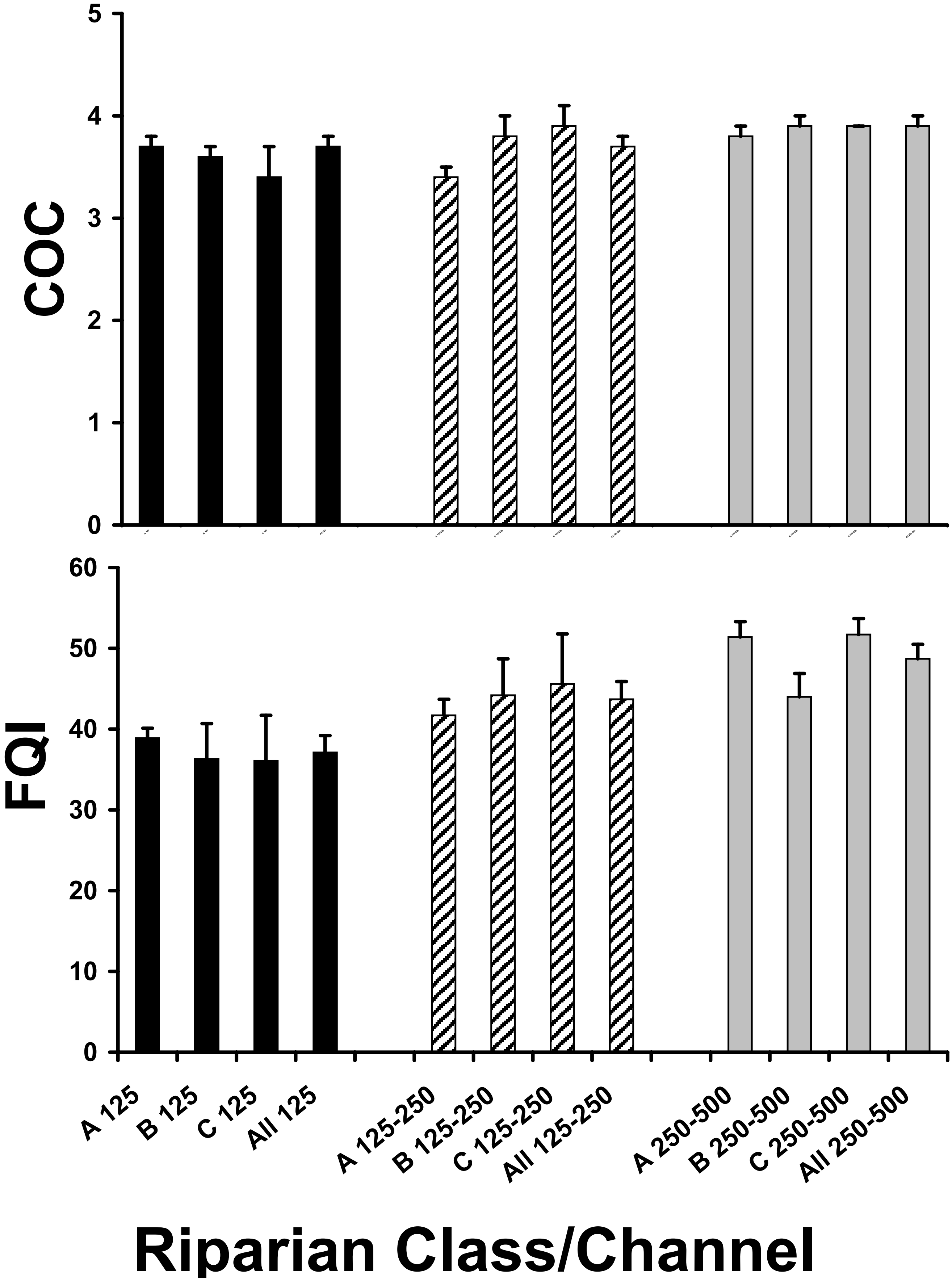

Figure 26. Comparisons of mean (+1 SE) Floristic Quality Index (FQI) scores and Coefficient of Conservatism (COC) among channel types (A, B and C) and buffer width classes (<125m black, 125-250m striped, 250-500m gray) for riparian survey areas visited in 2000 and 2001.

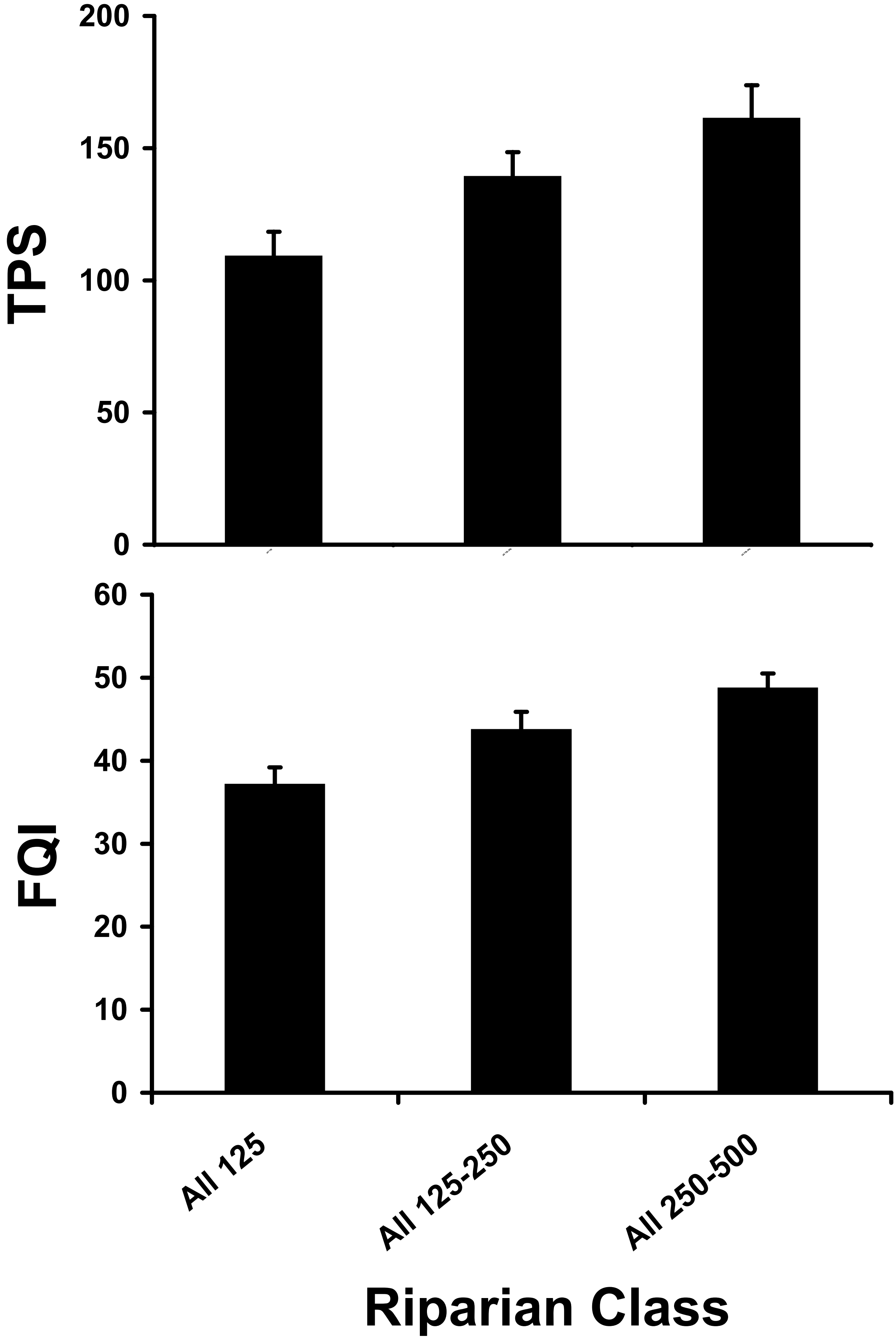

Figure 27. Mean (+1 SE) Floristic Quality Index (FQI) scores and total plant species richness (TPS) among buffer width classes (<125m, 125-250m, 250-500m) for riparian areas sampled in 2000 and 2001.

Vegetation and Floristic Sampling Results by Zone

Four different ecological zones were identified during this study: levee, forested bottom, sparsely forested bottom and upland forest. Means for plot data were calculated by zone for all vegetation parameters (Table 9). Groundcover typical of levees and forested bottoms included *Saururus cernuus* (lizard tail), *Laportea canadensis* (wood nettle), *Urtica dioica* (stinging nettle), *Arisaema dracontium* (green dragon), *Arisaema triphyllum* (Jack-in-the-pulpit), *Asarum canadense* (wild ginger), *Aster lateriflorus* (aster), *Carex grayi* (Gray's sedge), *Cinna arundinacea* (wood reedgrass), *Dioscorea villosa* (hairy wild yam), *Iris virginica* (southern blue-flag), *Pilea fontana* and *P. pumila* (clearweed), *Ranunculus hispidus* (swamp buttercup), *Smilax ecirrhata* (carrion flower) and *Verbesina alternifolia* (bellwort). Characteristic shrubs of these two ecological zones included *Lindera benzoin* (spice bush), *Cephalanthus occidentalis* (buttonbush), *Zanthoxylum americanum* (prickly ash), *Ilex verticilata* (Michigan holly), and *Carpinus caroliniana* (musclewood).

Levees were identified at only five sites: GR125-250, GR250-500, LG<125, RR<125 and TR125-250. The GR and LG sites were distinct sediment rises adjacent to the river, while the RR and TR levees were clearly artificial, created by the dredging of the river and formation of a spoils bank. The levees were narrow zones dominated by large diameter trees, typically *Acer saccharinum* (silver maple). Mean DBH was greatest for levees ($\bar{x}$ = 37.7±1.6 cm, Table 10). Levees were also characterized by a moderate diversity of understory species occurring at high densities. Other ecological measures for levees were similar to other zones identified in the study areas.

Of the 64 zones sampled during this study, 32 were identified as forested bottoms, and every site contained at least one forested bottom zone. The forested bottoms were the broadest of the zones, ranging from 20-306 m wide, and were typified by varying degrees of seasonal inundation. Forested bottoms were most frequently dominated by large diameter *Acer saccharinum* (silver maple) and *Fraxinus pennsylvanica* (green ash) in high densities and were characterized by sparse understory and ground layer vegetation. The forested bottoms had the greatest mean BA of all zones ($\bar{x}$=26.3±0.1 m^2/ha), which was significantly higher ($p<0.01$) than the mean BA of sparsely forested bottoms ($\bar{x}$=12.1±3.1 m^2/ha) (Table 10). The mean USSt ($\bar{x}$=22.3±2.7 stems/plot) was the lowest among zones and was significantly lower than the mean USSt for the upland forest zone ($\bar{x}$=36.2±3.6 stems/plot, $p<0.04$). The mean USSp ($\bar{x}$=4.7±0.4 species/plot) was also significantly lower than the mean USSp for the upland forest zone ($\bar{x}$=6.8±0.6 species/plot, $p<0.02$) (Table 10). Mean %GC ($\bar{x}$=41.8±4.3%) was the second lowest observed for all zones and was significantly lower than the sparsely forested bottom %GC ($\bar{x}$=70.3±11.5%, $p<0.04$) (Table 10).

Sparsely forested bottoms were narrow zones characterized by a scattered canopy of small diameter trees with open areas of high percent ground cover dominated by a diversity of herbaceous species or dense, diverse shrub thickets. There were only five zones across all study sites that were classified as sparsely forested bottom. These zones occurred in KZ<125, MR125-250, MR250-500, RC125-250 and RR250-500. The sparsely forested bottoms were characterized by the lowest mean BA ($\bar{x}$=12.1±3.1 m^2/ha) observed, and post hoc tests indicated that they had significantly lower mean BA than the levee ($p<0.01$), forested bottom ($p<0.001$) and upland ($p<0.001$) zones (Table 10). In comparison to other zones, mean GCS and %GC measures were high (Table 10). Mean %GC in the sparsely forested bottoms ($\bar{x}$=70.3±11.5%) was statistically higher than the mean %GC values for the forested bottom ($\bar{x}$=41.8±4.2%, $p<0.04$) and the upland zones ($\bar{x}$=34.9±3.8%, $p<0.009$).

Upland forest was the second most frequently observed ecological zone in the study (22 of 64 total zones). Upland forests were sampled in the final zones of all sites except GR<125, MR<125, RC<125, SJ<125 and TR<125. Upland forest zones were characteristically dominated in the overstory by a mix of mesic, mid-tolerant species such as *Tilia americana* (basswood), *Quercus rubra* (red oak), *Fraxinus americana*, (white ash) and *Prunus serotina* (black cherry), which are typical of second/third growth (previously logged) forests. The upland forest zones were predominantly narrow with diverse ground cover, diverse and dense understory vegetation, and a prevalent adventive species component due to upland forests acting as the edge zones of the forested buffer. The upland forest zone had a high mean BA ($\bar{x}$=25.6±1.1 m^2/ha), which was significantly higher than the mean BA of sparsely forested bottoms ($\bar{x}$=12.1±3.1 m^2/ha, $p<0.001$) (Table 10). The upland mean USSt ($\bar{x}$=36.3±3.6 stems/plot) and the mean USSp ($\bar{x}$=6.9±0.5 species/plot) were the highest among zones and were significantly higher than measures for the forested bottom zone ($p<0.04$ and $p<0.02$, respectively, Table 10). Mean %GC in the

Table 9. Summary of vegetation measures according to channel type. Parameters include basal area (BA), number of tree species/plot (NTS), diameter at breast height by prism plot (DBH), number of woody stems/plot (USSt), number of understory species/plot (USSp), number of ground cover species/plot (GCS) and the percentage of ground cover/ plot (%GC).

Channel Type	BA		NTS		DBH		USSt		USSp		GCS		%GC	
	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE
All	25.7	0.8	3.9	0.2	36.5	1.6	24.1	2.8	5.1	0.4	6.5	0.4	41.6	4.2
A	24.2	1.3	3.7	0.3	35.4	2.4	30.4	5.5	6.4	0.8	8.1	0.4	50.2	5.1
B	28.1	1.4	4.5	0.4	37.2	3.6	19.9	3.6	4.4	0.6	5.5	0.8	31.1	8.5
C	24.9	1.5	3.4	0.1	37.1	2.5	21.0	4.6	4.3	0.4	5.6	0.6	42.8	7.1

upland forest zone was the lowest observed ($\bar{x}$=34.9±3.8%) and was significantly lower than the mean %GC of sparsely forested bottoms ($\bar{x}$=70.6±11.5%, p< 0.009) (Table 10).

Terrestrial Vertebrate Results

Frog Survey Results

Eight frog species were detected during breeding frog call surveys and visual encounter surveys in 2001 (Table 11). The most common species, based on frequency of occurrence (i.e., number of sites at which a species was documented), were the wood frog (*Rana sylvatica*) and green frog (*Rana clamitans melanota*), observed at 14 of the 18 survey sites, followed by the northern spring peeper (*Pseudacris crucifer crucifer*), observed at 13 sites. The wood frog was observed predominantly during visual encounter surveys and was the most common species observed during these surveys. The least frequently encountered frog species were the northern leopard frog (*Rana pipiens*) and the bullfrog (*Rana catesbiana*), documented from only four sites and one site, respectively. The most abundant frog species heard during the frog call surveys were the northern spring peeper (n=269+), the western chorus frog (*Pseudacris triseriata triseriata*, n=95+), and the green frog (n=92+). Additional herp species were observed incidentally during the visual encounter surveys and aquatic surveys (Table 11). These included the common snapping turtle (*Chelydra serpentina serpentina*), common musk turtle (*Sternotherus odoratus*), eastern garter snake (*Thamnophis sirtalis sirtalis*) and northern water snake (*Nerodia sipedon sipedon*). No rare herp species were encountered at any of the study sites in 2001. However, a known population of the state-listed as special concern Blanchard's cricket frog (*Acris crepitans blanchardi*) was reconfirmed along the River Raisin in the vicinity of the study site during the frog call surveys.

Species richness of frogs per site, based on frog call and visual encounter surveys combined, ranged from one to seven species (Table 11). The MR250-500 and the TR125-250 sites had the highest frog species richness of all the sites surveyed. The overall mean species richness of frogs across all 18 study sites was 4.3± 0.4 species/site. Mean species richness of frogs was significantly different among riparian buffer width classes (F=4.76, p<0.04, Figure 29). The LSD post-hoc pairwise multiple comparison tests indicated the mean species richness of frogs in the 125-250m buffer width class was significantly higher than the mean species richness for the <125m buffer width class ($\bar{x}$=5.7±0.4 species and $\bar{x}$=3.2±0.7 species, respectively). The post-hoc analysis also provided marginal evidence to suggest that the mean species richness of frogs in the 125-250m riparian buffer width class was higher than that in the 250-500m buffer width ($\bar{x}$=4.0±0.7 species, p>0.06). The mean species richness of frogs in the <125m riparian buffer width class was not significantly different from that in the 250-500m buffer width class (p>0.30). ANOVAs for frog species richness data indicated no significant difference in these measures among channel types (F=3.4, p>0.08, Figure 29).

To examine the potential confounding factor of reduced frog call survey transect lengths (i.e., <1 km) at seven of the 18 study sites in the species richness analysis, an additional analysis with data from only the sites that contained 1-km survey transects was conducted. This analysis reduced the sample sizes for both the <125m buffer width and channel type B classes to only two sites. This analysis resulted in no significant differences in mean species richness of frogs among riparian buffer width classes or channel types (F=3.33, p>0.10 and F=1.49, p>0.30, respectively, Figure 30).

Minimum estimates of breeding frogs heard during call surveys ranged from zero to 66 individuals/night, with a mean of 13.5 individuals/night across all 18 study sites. Relative abundance measured as the mean number of frogs heard per night at a site ranged from zero to 42.5 individuals (Table 12). The MR250-500 and SH250-500 sites had the highest mean number

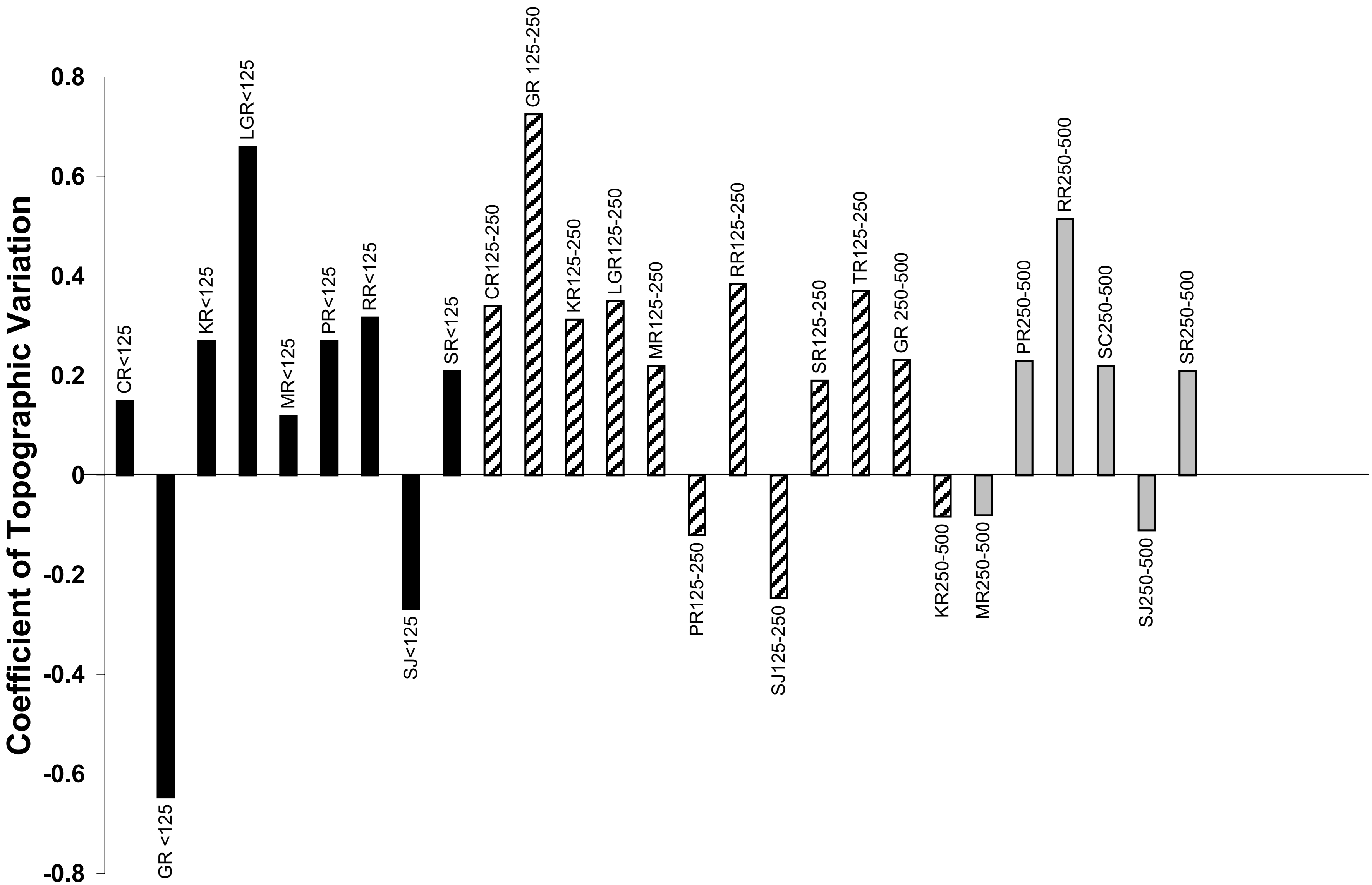

Figure 28. Coefficient of topographic variation for riparian survey areas visited in 200 and 2001, grouped by buffer width class (<125m black, 125-250m striped, 250-500m gray). Riparian survey areas visited included sites in the Grand, (GR), Kalamazoo (KR), Raisin (RR), St. Joseph (SJ), Pine (PR), Shiawassee (SH), Looking Glass (LG), Red Cedar (RC), Maple (MR), and Thornapple (TR) Rivers and Sycamore Creek (SC) wateshed.

Table 10. Means (±1 standard error, SE) for vegetation survey variables based on ecological zones observed in each riparian buffer width class. Vegetation parameters include basal area (BA), number of tree species per plot (NTS), tree diameter at breast height (DBH), number of understory woody stems/plot (USSt), number of understory species/plot (USSp), number of ground cover species (GCS) and percent ground cover (%GC).

Riparian Class	Ecological Zone	BA (m^2/ha)		NTS		DBH (cm)		USSt		USSp		CGS		%CG	
		MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE
<125m	Levee	23.0	2.8	3.6	0.0	41.2	1.9	30.2	12.8	7.4	4.0	6.4	2.0	63.6	7.0
	Forested Bottom	25.3	1.8	4.1	0.4	40.8	2.9	25.1	8.0	4.3	1.3	5.1	0.9	45.5	9.7
	Sparsely Forested Bottom	8.7	0.0	2.0	0.0	27.3	0.0	93.0	0.0	11.0	0.0	8.8	0.0	90.8	0.0
	Upland Forest	26.0	2.1	4.2	0.3	37.8	2.3	43.4	9.0	7.2	1.6	6.8	1.2	35.4	10.2
125-250m	Levee	25.9	5.7	3.2	0.8	34.9	0.3	20.3	19.7	1.6	1.2	6.1	7.9	40.7	16.1
	Forested Bottom	23.9	1.3	3.3	0.3	35.1	3.1	18.8	3.8	4.6	0.6	7.8	1.1	49.1	5.8
	Sparsely Forested Bottom	6.4	0.0	1.7	0.1	35.1	8.5	4.7	1.1	1.0	0.2	3.1	1.0	85.0	16.4
	Upland Forest	24.7	1.0	3.7	0.3	31.5	2.3	32.7	4.2	7.2	0.4	8.5	1.0	13.2	18.6
250-500m	Levee	19.3	0.0	4.0	0.0	36.1	0.0	50.8	0.0	7.2	0.0	11.4	0.0	28.4	0.0
	Forested Bottom	29.8	1.9	4.1	0.3	34.0	3.0	24.3	3.4	5.2	0.6	6.7	1.2	30.6	6.2
	Sparsely Forested Bottom	19.5	0.7	4.4	2.6	31.6	5.1	30.8	4.6	3.5	2.3	7.5	2.5	45.4	3.0
	Upland Forest	26.5	2.4	4.2	0.4	33.8	2.7	35.9	6.6	6.5	0.7	6.8	1.1	29.0	3.9
ALL	Levee	23.4	2.4	3.5	0.3	37.7	1.6	30.4	9.3	5.0	1.9	7.3	1.8	47.4	8.9
	Forested Bottom	26.3	1.0	3.8	0.2	36.1	1.8	22.3	2.7	4.7	0.4	6.8	0.6	41.8	4.3
	Sparsely Forested Bottom	12.1	3.1	2.8	1.0	32.1	3.5	32.8	16.2	4.0	3.1	6.0	1.5	70.3	11.5
	Upland Forest	25.6	1.1	4.0	0.2	33.8	1.5	36.3	3.6	6.9	0.5	7.5	0.6	34.9	3.8

Table 11. Presence/absence data and species richness of frogs observed at 18 riparian study sites representing three riparian buffer width classes (<125m, 125-250m, 250-500m) in 2001.

Frog Species		<125m						125-250m						250-500m					
Common name	Scientific Name	LG*	MR	PR	RC	SR	SJ	LG	MR	PR	RC	SR	TR	KZ	MR*	PR	SC	SR*	RR
Wood Frog	*Rana sylvatica*	C	V			V	V	C, V	V	V	C, V	V	V	V	C	C, V	V		
Northern Spring Peeper	*Pseudacris crucifer crucifer*	C					C	C	C	C	C	C	C	C	C	C		C	C
Western Chorus Frog	*Pseudacris triseriata triseriata*		C					C	C		C	C	C	C	C			C	C
Eastern Gray Treefrog	*Hyla versicolor*	C	C			C, I		C		C	C		C	I	C	C, I	C		
Northern Leopard Frog	*Rana pipiens*	C							C				C, V		C, I				
Eastern American Toad	*Bufo americanus americanus*		C	V, I	V	V	C	V	C		C		V	V, I	C, I	C, V			
Green frog	*Rana clamitans melanota*	C	C	V		V, I		C	C	V	C	C, V, I	C		C, I	C, V	C	C	
Bullfrog	*Rana catesbeiana*											C							
Additional herp species observed during visual encounter or aquatic surveys:																			
Common Snapping Turtle	*Chelydra serpentina serpentina*			I								I			I		I		
Common Musk Turtle	*Sternotherus odoratus*											I							
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*														I				
Northern Water Snake	*Nerodia sipedon sipedon*														I				
Total # of frog species (call surveys only)**		5	4	0	0	1	2	5	5	2	6	4	5	2	7	5	2	3	2
Total # of frog species (call and visual surveys)**		5	5	2	1	3	3	6	6	4	6	5	7	4	7	5	3	3	2

*Visual encounter surveys were not conducted at these sites due to unsuitable weather or site conditions.
**Total does not include incidental species.

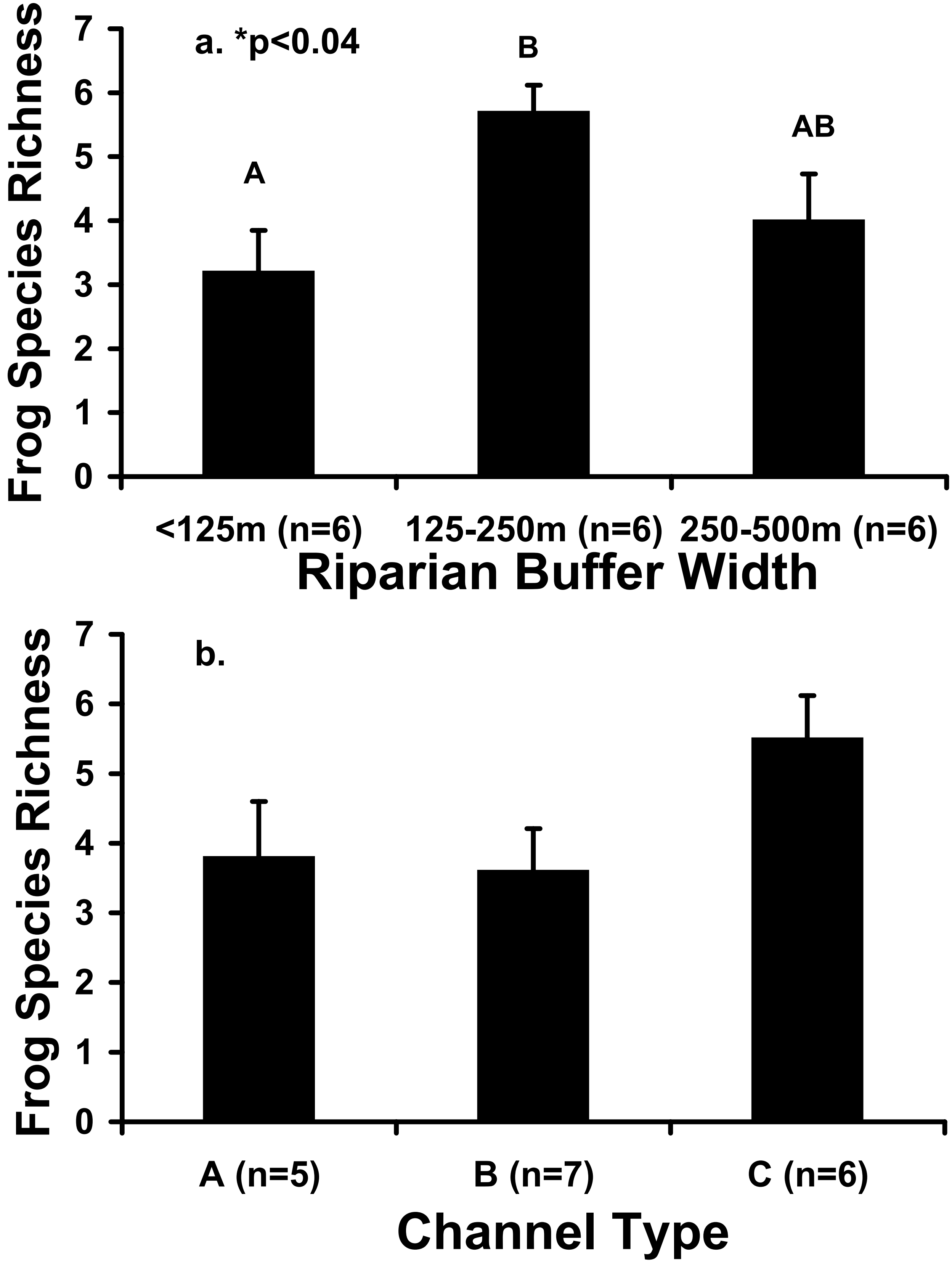

Figure 29. Comparisons of mean species richness of frogs (+1 SE) by (a) riparian buffer width and (b) channel type, based on combined results of breeding frog call surveys and visual encounter surveys at all 18 study sites. Letters reflect means that wer not significantly different at α=0.05.

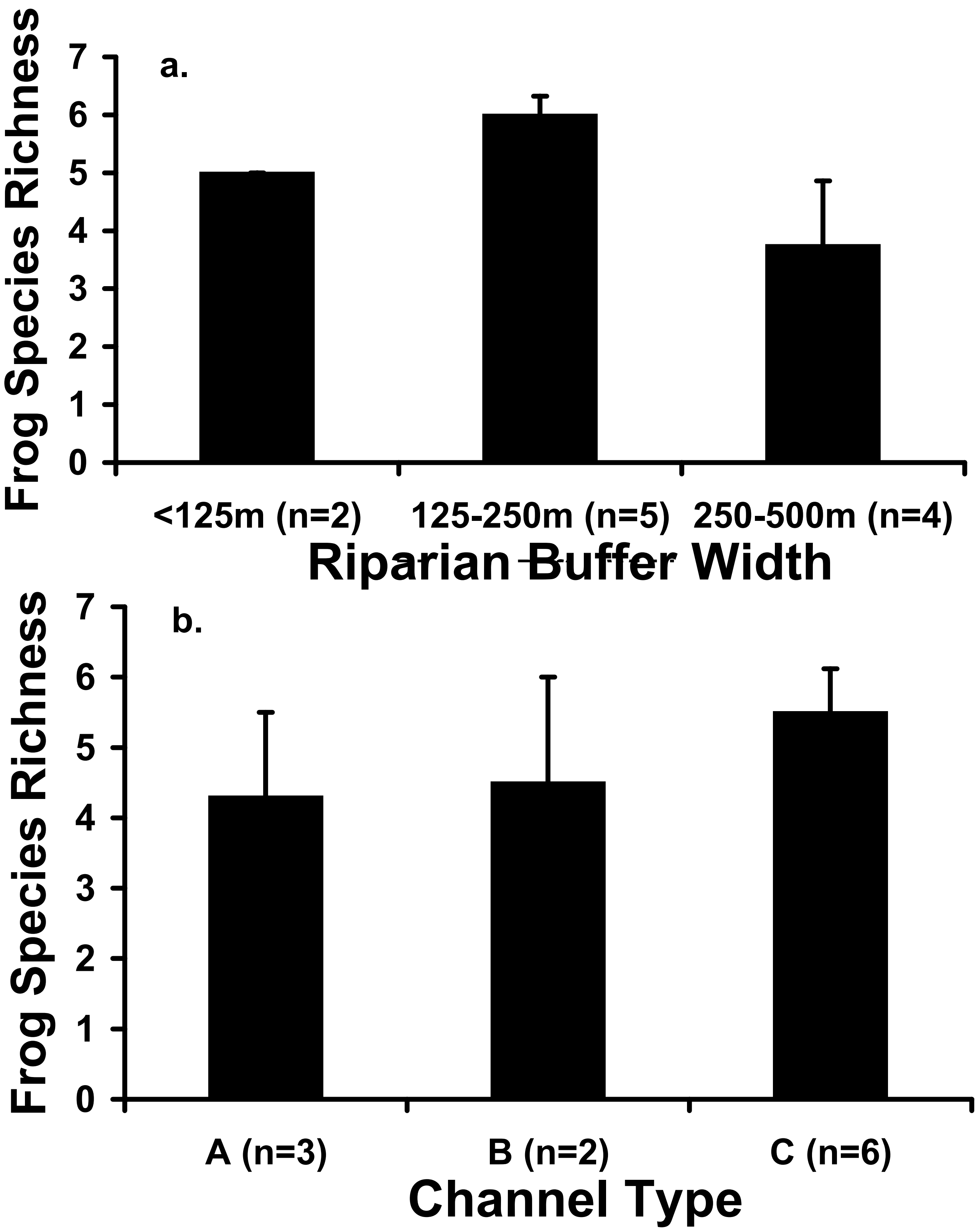

Figure 30. Comparisons of mean species richness of frogs (+1 SE) by (a) riparian buffer width and (b) channel type, based on combined results of breeding frog call surveys and visual encounter surveys only for sites with 1-km frog call survey transects (n=11). * indicates a significant difference with a two-way factorial ANOVA at α=0.05.

of frogs heard per night, with means of 42.5 and 33.5 frogs heard per night, respectively. Relative abundance of frogs observed during the visual encounter surveys ranged from zero to 10 individuals/ person-hour, with a mean of 3.6 individuals observed/ person-hour (Table 12). The TR125-250, SH<125\ and SJ<125 sites had the highest relative abundance of frogs observed during visual surveys, with 10.0, 9.5 and 8.0 individuals observed/person-hour, respectively.

The mean relative abundance of frogs in terms of the mean number of frogs heard per night differed significantly among riparian buffer width classes and channel types (F=5.36, p<0.03 and F=7.89, p<0.01, respectively, Figures 31 and 32). Post-hoc analysis indicated the mean relative abundance of frogs in the 250-500m riparian buffer width class ($\bar{x}$=21.7$\pm$6.3 indiv. heard/night) was significantly greater than the mean relative abundance of frogs in the <125m buffer width class ($\bar{x}$=6.3$\pm$3.7 indiv. heard/night, p<0.01) (Figure 31). There also was some evidence to suggest that the mean relative abundance of frogs in the 250-500m buffer width class was higher than that in the 125-250m buffer width class ($\bar{x}$=12.5$\pm$2.7 indiv. heard/ night), but this was not statistically significant (p>0.07). The mean relative abundance of frogs in the <125m and 125-250m buffer width classes were not significantly different (p>0.20).

Post-hoc analysis also indicated that the mean relative abundance of frogs for channel type C ($\bar{x}$=24.1$\pm$4.6 indiv. heard/night) was significantly greater than the mean for channel type A ($\bar{x}$=9.1$\pm$4.3 indiv. heard/night, p<0.02) and channel type B ($\bar{x}$=7.6$\pm$3.6 indiv. heard/night, p<0.005, Figure 32). Mean relative abundance measures of frogs for channel types A and B were not significantly different (p>0.70). Statistical analysis of the relative abundance data based on visual encounter surveys (i.e., number of frogs observed per person-hour) was also conducted, although no significant differences were detected among the riparian buffer width classes or channel types (F=0.40, p>0.65 and F=0.33, p>0.70, respectively, Figures 31 and 32).

To examine the potential effect of unequal or reduced call survey transect lengths on the relative abundance analysis, statistical analyses of the mean relative abundance of frogs heard/m/night and mean relative abundance of frogs heard/night for only the sites that had 1-km survey transects were conducted. There was some evidence to suggest that the mean relative abundance of frogs heard/m/night differed by riparian buffer width (F=4.0, p<0.06, Figure 31). Post-hoc tests indicated the mean number of frogs heard/m/ night was signifdicantly higher for the 250-500m buffer width class compared to the <125m buffer width class (p<0.02), although no difference was indicated between the 250-500m and 125-250m buffer width classes (p<0.10). Mean relative abundance of frogs heard/m/night did not differ significantly among channel types (F=2.7, p>0.10, Figure 32). Visual inspection of the mean relative abundance of frogs heard/m/night data indicated a possible outlier for channel type A (KZ250-500). Statistical analysis of the data excluding this observation indicated a significant difference in mean relative abundance of frogs heard/meter/night among channel types (F=9.0, p<0.01), with mean relative abundance for channel type C significantly greater than that for channel types A and B (p<0.01 for both).

Mean relative abundance of frogs heard/night among only the sites that had 1-km frog call survey transects differed significantly among channel types, but did not differ significantly among riparian buffer widths (F=15.13, p<0.02 and F=2.34, p>0.20, respectively, Figure 33). Post-hoc analysis indicated that the mean relative abundance of frogs for channel type C was significantly greater than that for channel types A and B (p<0.01 and p<0.04, respectively). However, the interaction between riparian buffer width and channel type also was significant (F=11.50, p<0.03). Statistical analysis to determine the basis for this interaction was conducted only for sites within the channel type C category due to sufficient, although small, sample sizes (n=2) for each buffer width. One-way ANOVA indicated a significant difference in mean relative abundances of frogs among riparian buffer widths within channel type C (F=15.39, p<0.03). Post-hoc analysis revealed that the mean relative abundance of frogs in the 250-500m buffer width class was significantly greater than that in the <125m and 125-250m buffer widths within the channel type C sites (p<0.02 for both). Visual inspection of the data also indicated the mean relative abundance of frogs for channel type C was higher than that for channel type A and lower than channel type B within the 125-250m buffer width class, but greater than that for channel types A and B in the 250-500m buffer width class. However, statistical comparisons of mean relative abundance of frogs among channel types within buffer width classes and among buffer widths within channel types A and B could not be conducted due to insufficient sample size (i.e., replicates of one in most cases).

Frog species richness was not significantly correlated with any of the terrestrial riparian habitat variables. However, the Spearman rank correlation analysis provided some evidence, although not conclusive, that species richness of frogs was negatively correlated with mean NTS (R=-0.55, p<0.02, Table 13). Relative abundance of frogs in terms of the mean number of frogs heard/night was significantly positively correlated with the TNPS and TPS (R=0.64, p<0.005 for both). The correlation analysis also suggested that relative abundance of frogs was positively correlated with the site FQI scores (R=0.57, p<0.02).

Breeding Bird Results

A total of 60 bird species was documented during the study (Appendix VIII). Species richness varied between a high of 20 breeding species (SH125-250) and a low of nine species (PR<125) (Table 14). The mean species richness across all study sites was 15.1 breeding species per site. The mean species richness was highest for the 250-500m riparian buffer width class with 16.0 species (Figure 34). The mean species richness for channel types was highest for type C with 17.8 species (Figure 34). The overall bird abundance varied between a high of 8.8 birds/point count station (SH250-500) and a low of 3.3 birds/station (MR125-250) (Table 14). The mean relative abundance across all sites was 6.1 breeding birds/station. The mean relative abundance was highest for the 250-500m buffer width class, with 6.4 birds/station (Figure 35). Channel type C had the highest mean relative abundance with 7.2 birds per station among all channel types (Figure 35).

The two-way factorial ANOVA revealed significant differences in bird species richness among riparian width classes (F=5.31, p<0.03) and channel types (F=26.62, p<0.001), as well as a significant interaction between riparian width and channel type (F=8.45, p<0.005). Separate analyses of variance isolated the interaction into three components. Bird species richness differed significantly among channel types within the <125m riparian width class (F=12.06, p<0.04). The mean species richness for channel type C appeared to be greater than that for channel types A and B, but insufficient sample size for channel type A (only 1 replicate) precluded any post-hoc analysis (Figure 34). A significant difference in species richness among channel types also occurred between the 125-250m and 250-500m riparian buffer width classes (F=22.33, p<0.02 and F=11.70, p<0.04, respectively). Mean species richness for channel type A and channel type C appeared to be significantly higher than that for channel type B within the 125m-250m buffer width class (p<0.01 and p<0.03, respectively) and within the 250-500m buffer width class (p<0.05 and p<0.02, respectively, Figure 34). Mean species richness was also significantly different among riparian width classes within channel type A (F=23.36, p<0.02). The data suggested bird species richness in the 125-250m buffer width class was higher than that in both the <125m and 250-500m buffer width classes (Figure 34). However, insufficient sample size for the <125m buffer width class in channel type A (only 1 replicate) precluded any post-hoc analysis.

Mean relative abundance of birds was not significantly different among riparian buffer width classes (F=0.85, p>0.45), but was significantly different among channel types (F=19.66, p<0.001, Figure 35). Post-hoc analysis indicated that relative abundance of breeding birds for channel types A and C were significantly higher than that for channel type B (p<0.01 and p<0.001, respectively, Figure 35). However, the interaction between riparian width and channel type was significant for bird abundance (F=6.11, p<0.02). Separate one-way ANOVA's indicated significant differences in mean bird abundances among channel types within the 125-250m and 250-500m buffer width classes (F=98.46, p<0.002 and F=22.27, p<0.02) and among buffer width classes within channel type C (F=17.56, p<0.03). Mean bird abundance was significantly greater for channel types A and C than that for channel type B within the 125-250m buffer width class (p<0.002 for both, Figure 35). However, within the 250-500m buffer width class, mean bird abundance was significantly higher for channel type C than that for both channel types A and B (p<0.025 and p<0.01, respectively, Figure 35). Mean bird abundance also was significantly higher in the 250-500m buffer width than that in the <125m and 125-250m buffer widths for sites within the channel type C category (p<0.015 and p<0.03, respectively, Figure 35).

Bird species richness was not significantly correlated with any terrestrial habitat parameters, although there was some evidence of a positive correlation with number of exotic species (R=0.54, p<0.03, Table 13). However, relative abundance of birds showed a significant positive correlation with TAPS in the riparian buffer (R=0.73, p<0.001, Table 13). The Spearman's rank correlation analysis also suggested a weak positive correlation between bird relative abundance and mean DBH and %GC (R=0.49, p<0.04 for both).

Spatial Analysis Results

Aquatic Community Spatial Analysis Results

Reach specific measures of aquatic community attributes were variably associated with landscape properties quantified over multiple upstream landscape contexts. HQI scores, MSR, RAIU, MBTI scores, FSR, FIBI scores, RAIB, INBI scores, EPT scores and RAIB were not significantly correlated (i.e.,

Table 12. Relative abundance of frogs detected during frog call surveys and visual encounter surveys at 18 study sites in three riparian buffer width classes (<125m, 125-250m, 250-500m) in 2001. Relative abundance measures reflect minimum estimates.

Frog Species		**<125m**						**125-250m**						**250-500m**						
Common name	**Scientific Name**	**LG***	**MR**	**PR**	**RC**	**SR**	**SJ**	**LG**	**MR**	**PR**	**RC**	**SR**	**TR**	**KZ**	**MR***	**PR**	**SC**	**SR***	**RR**	**Total**
Wood Frog	*Rana sylvatica*	4	0, 1			0, 12	0, 16	2, 5	0, 2	0, 1	2, 6	0, 1	0, 18	0, 6	1	4, 2	0, 2			13, 72
Northern Spring Peeper	*Pseudacris crucifer crucifer*	5					2, 0	18+, 0	8, 0	15+, 0	12, 0	2, 0	22, 0	41+, 0	33+	52+, 0		47+, 0	12, 0	269+, 0
Western Chorus Frog	*Pseudacris triseriata triseriata*		31, 0					9, 0	6, 0		13+, 0	1, 0	1, 0	7, 0	15			8, 0	4, 0	95+, 0
Eastern Gray Treefrog	*Hyla versicolor*	11	18, 0			1, 0, (13)		3, 0		2, 0	19, 0		4, 0	(1)	1	3, 0, (1)	2, 0			64, 0, (15)
Northern Leopard Frog	*Rana pipiens*	2							4, 0				3, 1		5, (1)					14, 1, (1)
Eastern American Toad	*Bufo americanus americanus*		4, 0	0, 5, (1)	0, 3	0, 3	1, 0	0, 2	18+, 0		1, 0		0, 1	0, 1, (1)	12, (1)	2, 1				38+, 16, (3)
Green frog	*Rana clamitans melanota*	23	9, 0	0, 1		0, 1, (17)		6, 0	5, 0	0, 2	3, 0	3, 1, (5)	2, 0		18, (1)	4, 1	7, 0	12, 0		92, 6, (23)
Bullfrog	*Rana catesbeiana*											1, 0								1, 0
Unidentified	*Rana* sp.				0, 6	0, 3											0, 3			0, 12
Additional herp species observed during visual encounter or aquatic surveys:																				
Common Snapping Turtle	*Chelydra serpentina serpentina*			(1)								(1)			(6)		(2)			(10)
Common Musk Turtle	*Sternotherus odoratus*											(1)								(1)
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*														(1)					(1)
Northern Water Snake	*Nerodia sipedon sipedon*														(1)					(1)
Total # of frogs**		**45**	**62, 1**	**0, 6, (1)**	**0, 9**	**1, 19, (30)**	**3, 16**	**38+, 7**	**41+, 2**	**17+, 3**	**50+, 6**	**7, 2, (5)**	**32, 20**	**48+, 7, (2)**	**85+, (3)**	**65+, 4, (1)**	**9, 5**	**67+,**	**16, 0**	**586+, 107, (42)**
Mean # of frogs heard / night		15.0	20.7	0.0	0.0	0.5	1.5	12.7	20.5	5.7	16.7	3.5	16.0	24.0	42.5	21.7	3.0	33.5	5.3	13.5
Mean # of frogs heard / meter / night		0.015	0.021	0.000	0.000	0.001	0.002	0.013	0.021	0.008	0.017	0.004	0.016	0.044	0.043	0.027	0.003	0.034	0.005	0.015
# frogs visually observed /person-hour		*	0.5	3.0	4.5	9.5	8.0	3.5	1.0	1.5	3.0	1.0	10.0	3.5	*	2.0	2.5	*	0.0	3.6

*Visual encounter surveys were not conducted at these sites due to unsuitable weather or site conditions.

**Totals do not include incidental species/observations.

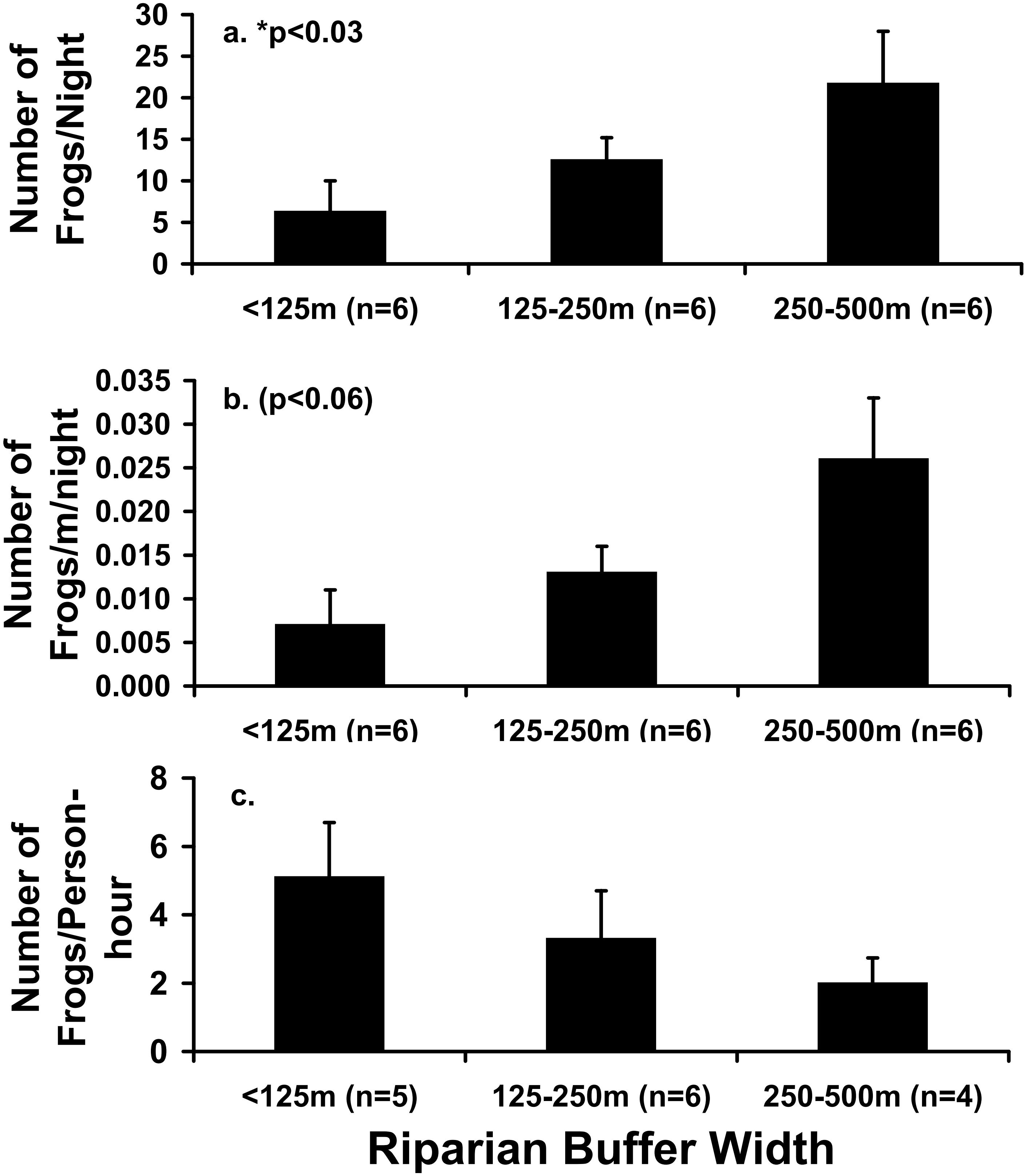

Figure 31. Comparisons of relative abundance of frogs by riparian buffer width based on (a) mean number of frogs heard per night (+1 SE) during breeding frog call surveys (FCS), (b) mean number of frogs heard per meter per night (+1 SE) during FCS, and (c) mean number of frogs observed per person-hour (+1 SE) during visual encounter surveys (VES). * indicates a significant difference with a two-way factorial ANOVA at α=0.05.

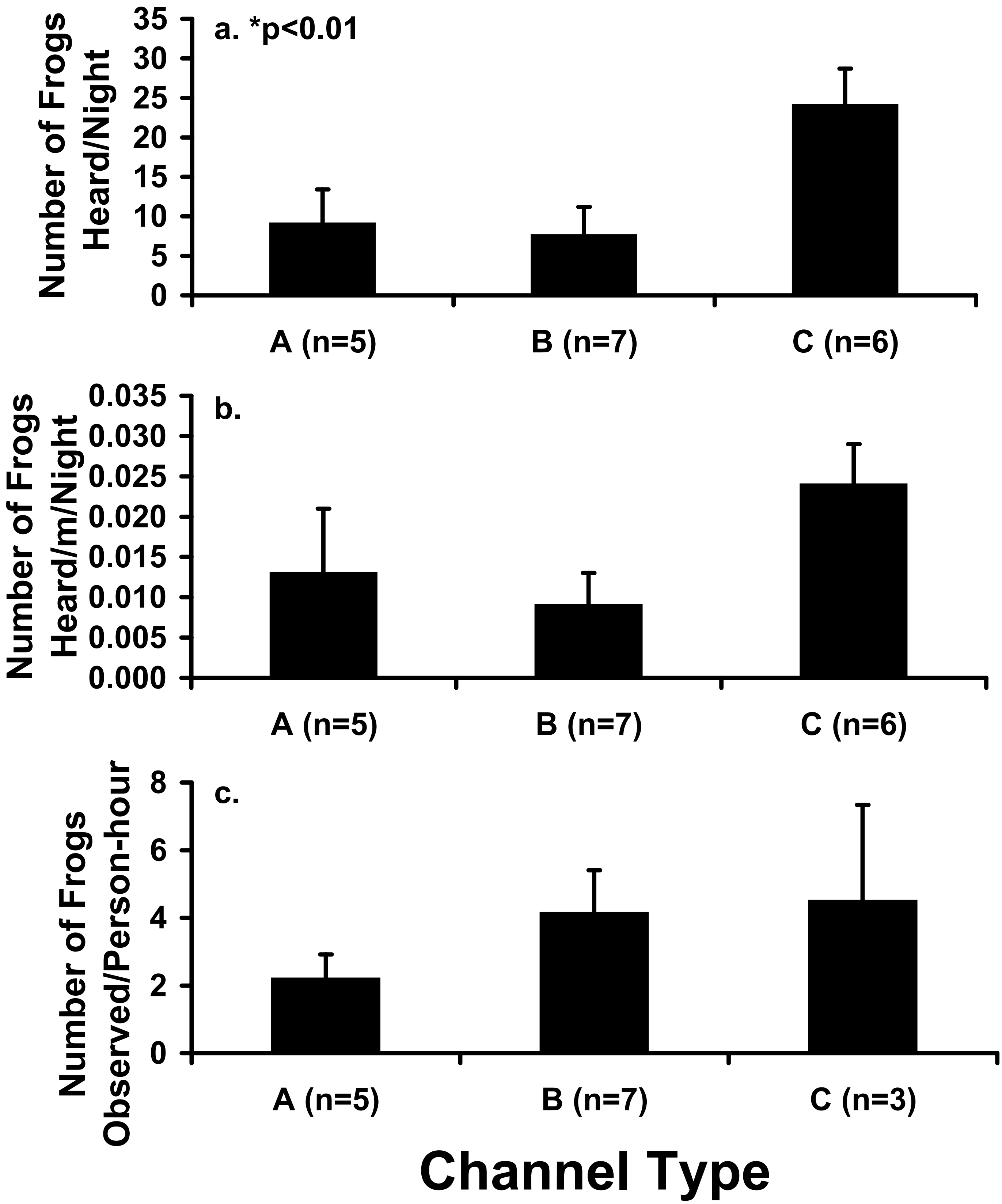

Figure 32. Comparisons of relative abundance of frogs by channel type based on (a) mean number of frogs heard per night (+1 SE) during breeding frog call surveys (FCS), (b) mean number of frogs heard per meter per night (+1 SE) during FCS, and (c) mean number of frogs observed per person-hour (+1 SE) during visual encounter surveys (VES). * indicates a significant difference with a two-way factorial ANOVA at α=0.05.

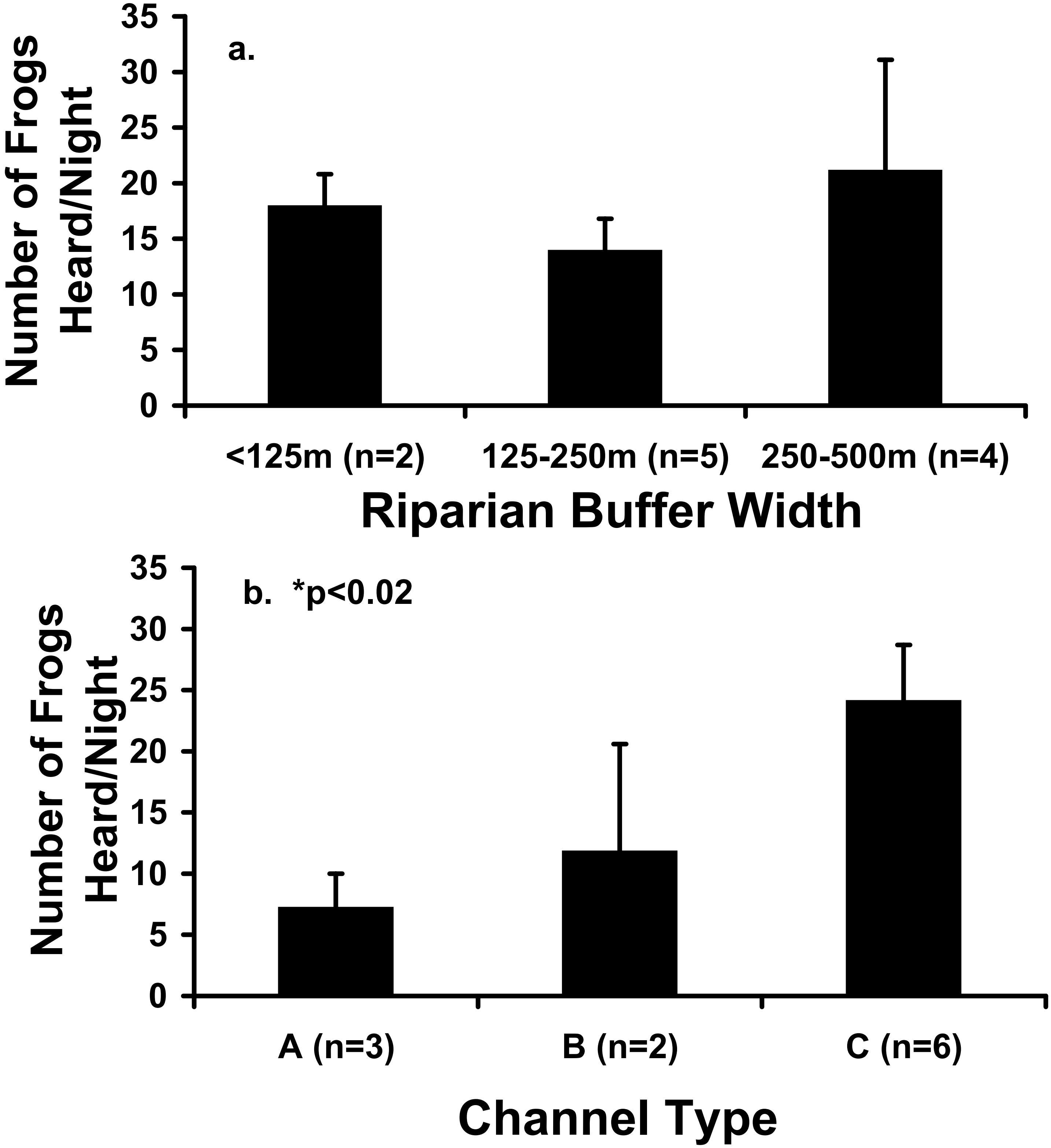

Figure 33. Comparisons of relative abundance of frogs (mean # of frogs heard per night +1 SE) by (a) riparian buffer width and (b) channel type, based on breeding frog call surveys, for only sites with 1-km survey transects (n=11). * indicates a significant difference with a two-way factorial ANOVA at α=0.05.

Table 13. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with terrestrial vertebrate species richness and relative abundance within the <125m, 125-250m and 250-500m riparian buffers at the 18 terrestrial vertebrate study sites. Significant correlations are highlighted in gray (p<0.005). Community parameter descriptions are provided within the report text.

Habitat Variable	Frog Species Richness[1]	Frog Relative Abundance[2]	Bird Species Richness[3]	Bird Relative Abundance[4]
# Zones	R=0.37 p>0.13	R=0.38 p>0.12	R=0.20 p>0.41	R=0.05 p>0.83
CTV	R=0.18 p>0.47	R=-0.06 p>0.80	R=0.09 p>0.72	R=0.09 p>0.71
CTV (ABS)	R=0.06 p>0.82	R=-0.26 p>0.29	R=-0.03 p>0.89	R=0.07 p>0.77
BA	R=-0.35 p>0.15	R=-0.25 p>0.31	R=-0.08 p>0.72	R=-0.32 p>0.19
TSP	R=-0.55 p<0.02	R=-0.26 p>0.30	R=-0.30 p>0.23	R=-0.24 p>0.32
DBH	R=-0.10 p>0.69	R=-0.14 p>0.57	R=0.17 p>0.50	R=0.49 p<0.04
USSt	R=-0.33 p>0.18	R=-0.12 p>0.64	R=0.02 p>0.92	R=0.37 p>0.13
USSp	R=-0.30 p>0.23	R=-0.32 p>0.19	R=-0.09 p>0.70	R=0.14 p>0.57
GCS	R=0.09 p>0.73	R=0.13 p>0.60	R=0.17 p>0.49	R=0.09 p>0.72
TNPS	R=0.36 p>0.14	R=0.64 p<0.005	R=0.37 p>0.13	R=0.34 p>0.16
TAPS	R=0.01 p>0.97	R=-0.09 p>0.73	R=0.54 p<0.025	R=0.73 p<0.002
TPS	R=0.41 p>0.09	R=0.64 p<0.005	R=0.44 p<0.07	R=0.41 p>0.09
%NPS	R=0.17 p>0.49	R=0.33 p>0.17	R=-0.23 p>0.36	R=-0.34 p>0.17
%EPS	R=-0.17 p>0.49	R=-0.33 p>0.17	R=0.23 p>0.36	R=0.34 p>0.17
FQI	R=0.29 p>0.24	R=0.57 p<0.015	R=0.31 p>0.21	R=0.32 p>0.19
COC	R=0.20 p>0.42	R=0.22 p>0.37	R=-0.11 p>0.65	R=-0.03 p>0.89

[1]Total number of frog species recorded during breeding frog call surveys and visual enc

[2]Mean number of frogs heard per night during breeding frog call surveys.

[3]Total number of bird species observed per site during breeding bird point counts.

[4]Average number of birds per point count.

Table 14. Summary of species richness and relative abundance results from breeding bird surveys.

River	Riparian Width	Channel Type	Season	Species Richness*	Relative Abundance**
Maple	<125m	C	Breeding	18	6.2
Maple	125-250m	B	Breeding	10	3.3
Maple	250-500m	C	Breeding	18	8.2
Pine	<125m	A	Breeding	9	6.5
Pine	125-250m	B	Breeding	12	3.5
Pine	250-500m	B	Breeding	14	5.2
Shiawassee	<125m	B	Breeding	10	4.3
Shiawassee	125-250m	A	Breeding	20	7.0
Shiawassee	250-500m	C	Breeding	19	8.8
Looking Glass	<125m	C	Breeding	19	6.3
Looking Glass	125-250m	A	Breeding	18	7.8
Kalamazoo	250-500m	A	Breeding	17	5.5
Red Cedar	<125m	B	Breeding	14	6.8
Red Cedar	125-250m	C	Breeding	16	7.2
Sycamore	250-500m	B	Breeding	11	4.3
St. Joseph	<125m	B	Breeding	13	6.3
Thornapple	125-250m	C	Breeding	17	6.5
Raisin	250-500m	A	Breeding	17	6.3

***Species Richness** = total number of species observed per site.
****Relative Abundance** = average number of birds per point count. Average calculated by counting total number of birds within three 50m point count plots and dividing by total number of point counts per site.

p>0.005) with any land cover properties measured within buffers of any width or upstream spatial extent (Appendices IX-XIII). TASR measures were negatively correlated with the spatial extent of forest land covers within the 120-m and 240-m buffers for the local spatial context ($R=-0.59$, $p<0.002$, $R=-0.56$, $p<0.004$, respectively, Figure 36). They were also negatively correlated with the extent of the combined forest-wetland land covers within the 120-m buffer area of the local landscape context ($R=-0.54$, $p<0.005$, Appendix XIII). TASR measures were positively correlated with the spatial extent of agricultural land covers within the 120-m, 240-m and 480-m buffers of the local landscape context ($R=0.60$, $p<0.002$, $R=0.60$, $p<0.002$ and $R=0.57$, $p<0.003$, respectively, Appendix IX).

MSR was not significantly correlated with any of the land covers within buffers across all landscapes contexts (Appendices IX-XIII). The strongest correlations observed between MSR and landscape parameters occurred within the U/S-3 landscape context, where MSR was weakly correlated with the spatial extent of forest land covers within 30-m, 60-m and 120-m buffers ($R=0.48$, $p<0.015$, $R=0.46$, $p<0.017$, and $R=0.47$, $p<0.015$, respectively, Appendix XI) and wetland land covers within the 60-m buffer ($R=-0.48$, $p<0.013$). RAIU measures showed only a weak positive correlation with the extent of forest land covers within the 960m buffer of the U/S-2 landscape context ($R=-0.49$, $p<0.011$). RATU measures showed a weak negative correlation with the spatial extent of wetlands within 120-m buffers of the U/S-1 landscape context ($R=-0.49$, $p<0.011$), and also showed a marginal positive correlation with the spatial extent of forest land covers within 240-m buffers of the U/S-2 landscape context ($R=0.50$, $p<0.009$). MBTI scores were only marginally correlated the extent of forest land covers within 30-m buffers of the local landscape context ($R=0.49$, $p<0.01$). MCPUE exhibited the strongest correlations with land cover properties of buffers compared to all other mussel community parameters. MCPUE showed significant positive correlations with the agricultural land cover component of 480-m and 960-m buffers for the U/S-2 landscape context ($R=0.59$, $p<0.002$, $R=0.58$, $p<0.003$, respectively, Figure 37).

FCPUE was the only fish metric to show a weak correlation with land cover properties of buffers over

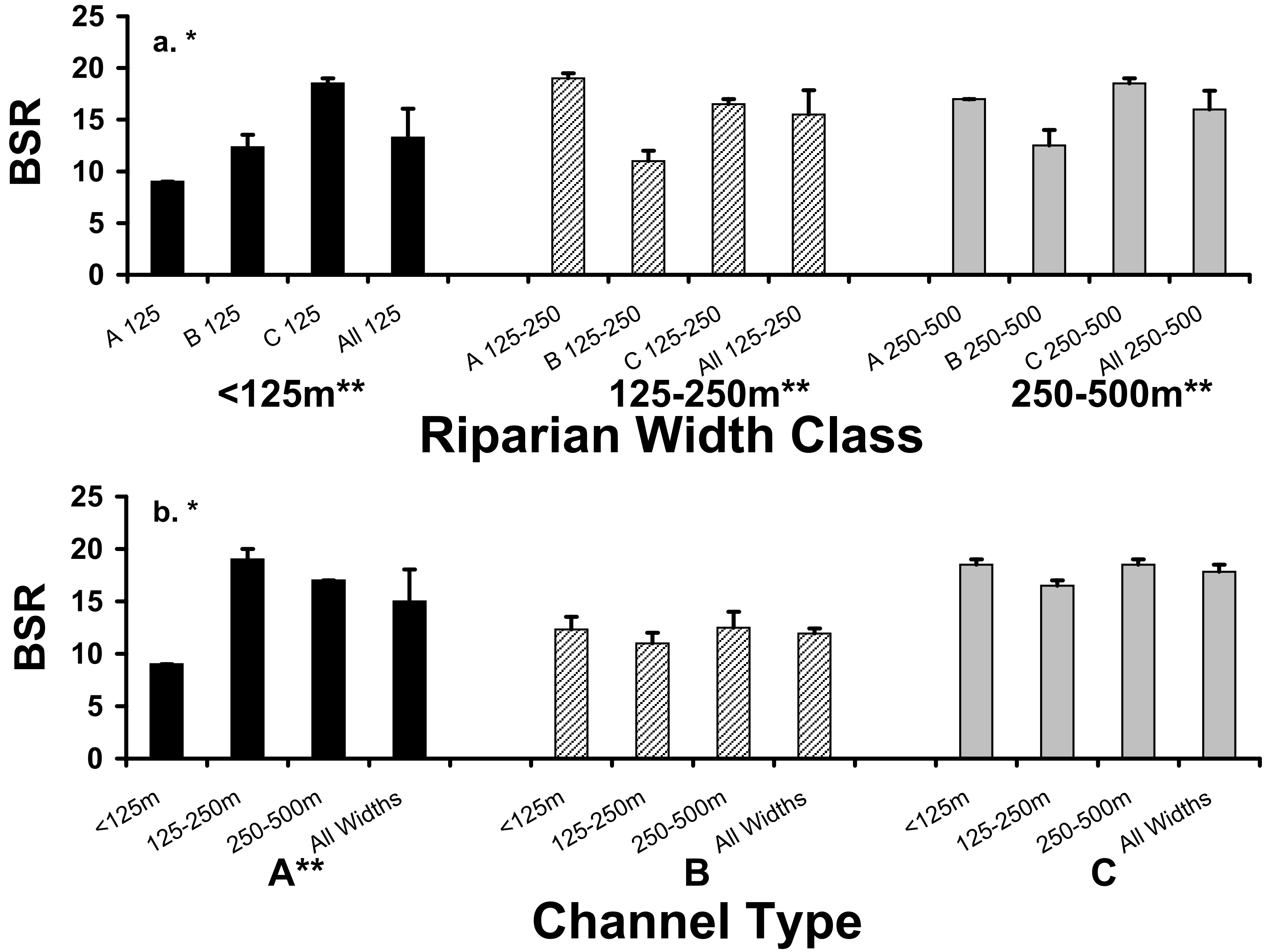

Figure 34. Comparisons of mean (+SE) bird species richness (BSR) by (a) riparian buffer width (<125m, 125-250m and 250-500m) grouped by channel type (A, B and C) and (b) by channel type grouped by riparian buffer width. * indicates a significant difference with a two-way factorial ANOVA at $p<0.05$. ** indicates a significant difference with separate one-way ANOVA's at $p<0.05$.

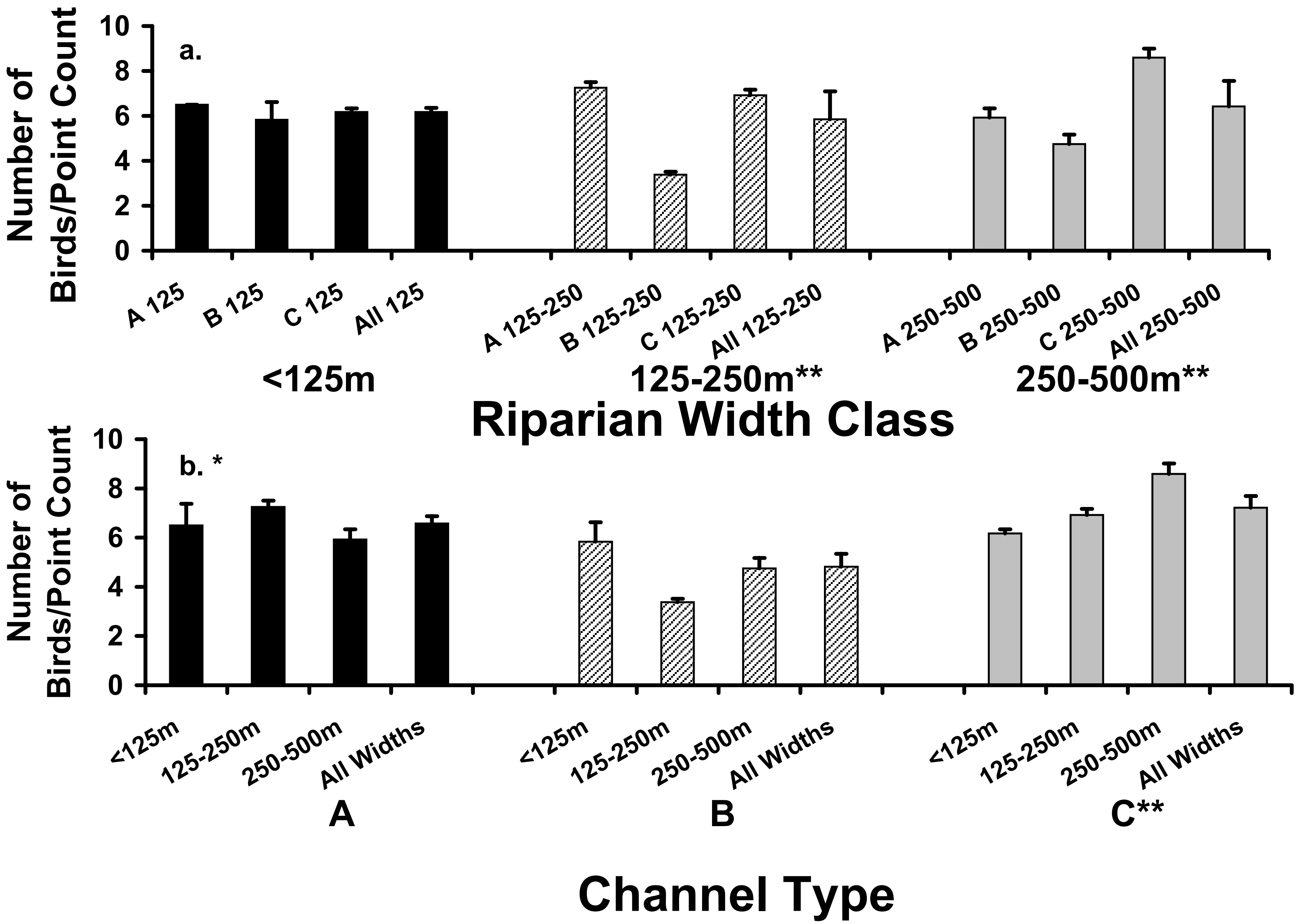

Figure 35. Comparisons of mean relative abundance of birds (+1 SE) by (a) riparian buffer width (<125m, 125-250m and 250-500m) grouped by channel type (A, B and C) and (b) by channel type grouped by riparian width. * indicates a significant difference with a two-way factorial ANOVA at $p<0.05$. ** indicates a significant difference with separate one-way ANOVA's at $p<0.05$.

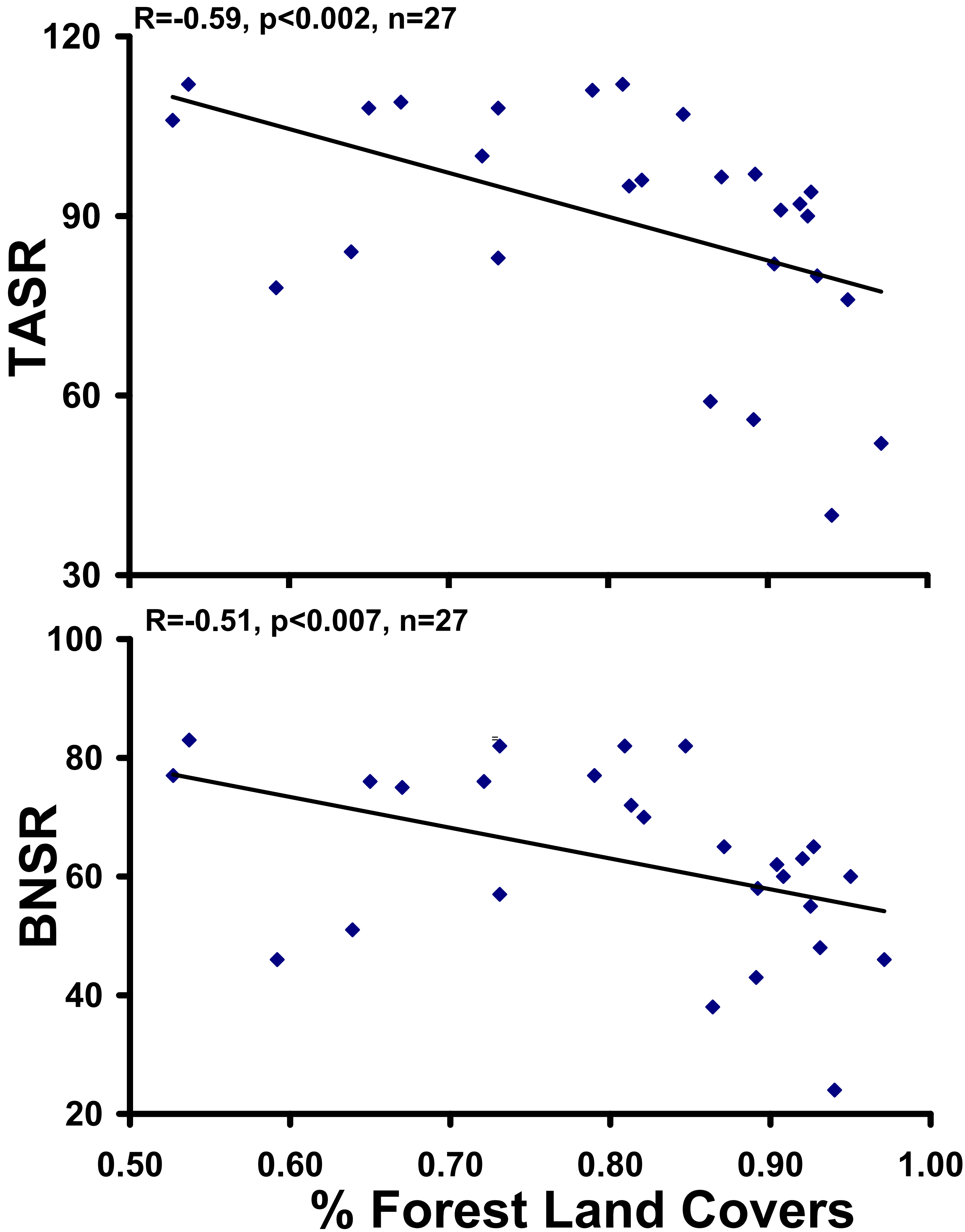

Figure 36. Correlations between total aquatic species richness (TASR) and benthic species richness (BNSR) and the extent of forest land covers within 120m buffers of the local landscape context for streams characterized by varied riparian and channel properties. Correlations were considered significant at $\alpha<0.005$.

any landscape context. FCPUE showed a weak positive correlation with spatial extent of all modified land covers comprising buffers of the U/S-1 landscape context ($R=0.49$, $p<0.011$). BNSR measures were most strongly correlated with the spatial extent of agricultural land covers within 120-m, 240-m and 480-m buffers of the U/S-1 landscape context ($R=0.58$, $p<0.003$, $R=0.57$, $p<0.003$, $R=0.57$, $p<0.003$, respectively, Figure 37). BNSR also showed marginal correlations with the forest component of 120-m and 240-m buffers of the U/S-1 context ($R=-0.51$, $p<0.007$ and $R=-0.50$, $p<0.10$, respectively) and the wetland component of 480-m buffers of the U/S-1 context ($R=0.52$, $p<0.006$). EPT index measures were the only other benthic community parameter that showed a correlation with land cover properties of buffers, exhibiting a weak positive correlation with agricultural land covers within 120-m buffers of the U/S-1 landscape context ($R=0.49$, $p<0.01$).

<u>Terrestrial Community Spatial Analysis Results</u>

Terrestrial community parameters were variably associated with the spatial extent of land covers comprising stream buffers of varying width quantified over multiple spatial contexts. Most site vegetation sampling measures were not associated with buffer land cover properties of local or upstream spatial contexts (Appendix IX-XIII). USSt measures were most closely associated with agricultural land covers of the U/S-1 and U/S-2 landscape contexts, although most of these associations were marginal with only one significant correlation detected with the U/S-1 30-m buffer ($R=-0.52$, $p<0.007$) (Appendix IX). The number of microtopographic zones present was most closely associated with the extent of forest land covers within the local landscape context, particularly the Local 240-m buffer ($R=0.51$, $p<0.008$) (Appendix XI). DBH measures were negatively correlated with the extent of forest land covers within the local 60-m buffers ($R=-0.57$, $p<0.003$) and were positively correlated with the extent of all modified land covers within local 30-m and 60-m buffers ($R=0.52$, $p<0.007$, $R=0.60$, $p<0.002$, respectively) (Appendix X).

Floristic measures were significantly correlated with the spatial extent of several land cover types within buffers over multiple landscape contexts (Appendices IX-XIII). TPS and TNPS measures were negatively associated with the extent of agricultural land covers within most local buffers (Appendix IX) and were also negatively associated with the spatial extent of modified land covers within all local buffers and the larger buffer areas of the U/S-1,U/S-2 and U/S-3 landscape contexts (Appendix X). TPS and TAPS were also positively correlated with the spatial extent of forest land covers within larger buffers of the local and U/S-1 landscape contexts (Appendix XI). TPS and TNPS were also positively correlated with the extent of forest/wetland land covers within all local buffer areas and the larger buffers of the U/S-1 and U/S-2 landscape contexts (Appendix XIII). The percentage of native plant species at sites was positively correlated with the spatial extent of the combined forest/wetland land covers within most buffers of the U/S-1 landscape context and the 480-m buffer of the U/S-2 landscape context (Appendix XII). The percentage of adventive plant species at sites followed the opposite pattern (Appendix XII). FQI scores were negatively associated with the extent of agricultural land covers within all buffers of the local landscape context (Appendix IX) and were negatively associated with the spatial extent of modified land covers within all local landscape contexts and the larger buffer areas of U/S-1, U/S-2 and U/S-3 landscape contexts (Appendix X). FQI measures were positively correlated with the spatial extent of forests within most buffers of local and the larger buffers of U/S-1, U/S-2, and U/S-3 landscape contexts (Appendix XI). FQI scores were also positively correlated with the spatial extent of the combined forest/wetland land covers of all local buffer areas as well as the larger buffer areas of the U/S-1, U/S-2 and U/S-3 landscape landscapes (Appendix XIII).

Bird and herptile species richness were not significantly correlated with land cover types of buffers within all landscape contexts (Appendices IX-XIII).

DISCUSSION

Summary

The most widely accepted definition for biodiversity is "the variety of life and all its forms, levels and combinations," including the various ecological functions that serve to support its long-term viability (IUCN, UNEP and WWF, 1991). For most contemporary North American landscapes, benchmarks that reflect pristine levels of biodiversity are scarce. Accordingly, biodiversity must generally be measured in a relative sense in order to explore biodiversity patterns relative to environmental properties of landscapes. There is little question that the viability of populations of native species supported by high levels of ecological function is desirable from a natural resource management perspective. Thus, we attempted to describe the biodiversity of riparian areas in southern Lower Michigan through observations of species richness and ecological and biological integrity measures based on community structure in both

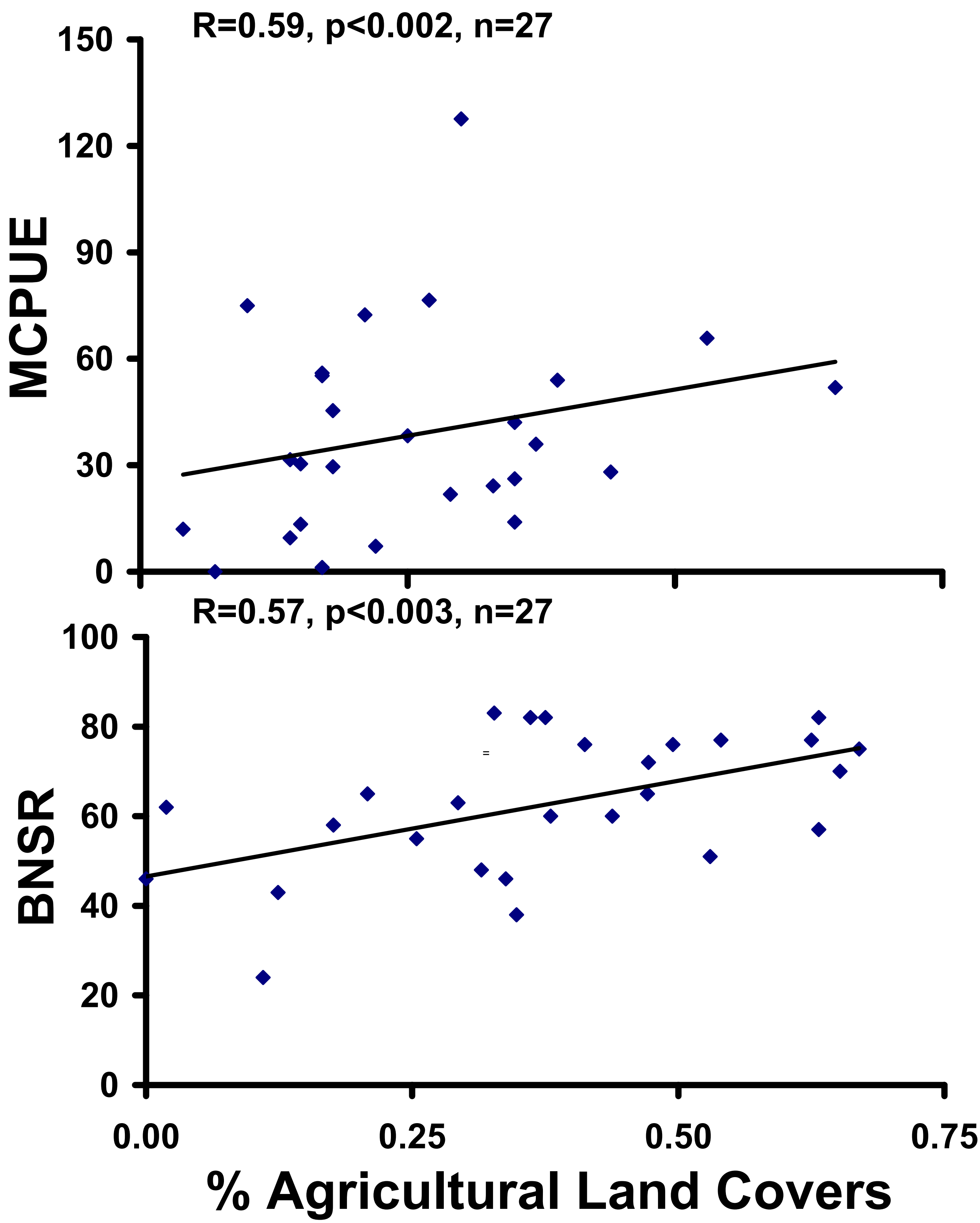

Figure 37. Correlations between mussel catch per unit effort (MCPUE) and the extent of agricultural land covers within 480-m buffer areas within the US-2 landscape context (a) and between benthic species richness (BNSR) and the extent of agricultural land covers within 960-m buffers of the local landscape context for streams characterized by varied riparian and channel properties. Correlations were considered significant at $\alpha<0.005$.

terrestrial and aquatic environments. While the efficacy of these measures as viable representations of biodiversity can be debated at length, we believe that they have merit and enabled us to effectively evaluate the varied abilities of riparian corridors for sustaining native biodiversity within the context of a fragmented landscape.

Overall, the results of this study provided some support for the idea that biodiversity refuge potential of riparian corridors within fragmented landscapes can be predicted based solely on corridor width and contiguity, primairly with respect to terrestrial flora and some vertebrate groups. This largely agreed with other studies that have documented the importance of riparian corridors to biodiversity (Carothers et al. 1974, Carothers and Johnson 1975, Kauffman and Krueger 1984, Doyle 1990, Olson and Knopf 1988, Bratton et al. 1994). In many cases, however, terrestrial vertebrate analyses indicated significant interactions between riparian width class and channel type, indicating varied reponses of these groups over varied combinations of the main effects. Regardless, the overall results for these vertebrate groups gave credence to the idea that wider riparian corridors support greater species richness and relative abundance of herptiles (but see Burbrink et al. 1998).

While there were no significant differences in aquatic community parameters among riparian width classes, this was not especially surprising given that riparian influences are generally greater in smaller, headwater streams compared to the mid-size streams included in this study (e.g., Vannote et al. 1981). Instead, aquatic community measures were generally more responsive to the channel characteristics of sites rather than riparian buffer width class. Vegetation parameters were also not significantly different among riparian width classes and appeared to be more responsive to within-site ecological zonation.

For groups that did not exhibit significantly greater species richness or relative abundance in wider riparian areas, this may be due to nominal increases in species richness beyond a spatial threshold in riparian landscapes. Riparian areas have been shown to support twice the number of species that are found in surrounding upland areas (Gregory et al. 1991). While wider riparian corridors encompass greater land areas (and presumably greater available habitat for species), increasing levels of biodiversity may be nominal once the upland zone is incorporated into these corridors. Therefore, the overall biodiversity potential of these areas does not necessarily increase with increasing riparian buffer width. However, for terrestrial flora and some vertebrates, this was not the case in this study, and there appear to be benefits for managing wider vs. narrower buffers to enhance the conservation of these taxa.

Another factor that may have contributed to the lack of significant differences in community/ecological measures in response to varied riparian properties was related to the remotely sensed selection criteria for study sites (i.e., riparian corridor width and connectivity). A few of the sites chosen based on topographic maps and aerial photos had local habitat properties that departed from the hypothesized pattern of higher quality instream habitat in streams with wider adjacent riparian forest buffer zones. For example, stream reaches that had been previously dredged had greatly altered benthic habitats. No stable benthic substrate could be identified for such sites and mussel surveys could not be performed. Additionally, woody debris and snags were the only stable substrates for macroinvertebrate colonization. In addition, spoils piles resulting from the dredging activities altered local microtopography and ecological zonation of sites. While dredged channels are often readily detected through topographic map and aerial photograph interpretation, they were not detected during site selection for this study. Thus, the potential for undetectable (at least with respect to remote sensing interpretation) dredged channels within riparian corridors serves as an impediment to the detection of high levels of biodiversity based on riparian corridor width and connectivity. The significance of this observation is that it indicates that any efforts to select priority stream biodiversity sites for conservation should be tempered with caution and that efforts to ground truth selected sites should be conducted. However, by combining these remote-sensing techniques to evaluate coarse landscape features (i.e., riparian corridor properties) with reconnaissance visits to selected sites, the potential biodiversity value of sites, particularly with regard to aquatic environments, may be appropriately assessed. Regardless, the results of our analyses suggest that identifying aquatic biodiversity based solely on riparian properties interpreted from remote-sensing data sources could not be reliably done within southern Lower Michigan's fragmented landscape.

Although large-scale, ecosystem-level conservation efforts are vital for enhancing the long-term viability of native taxa, communities and ecosystems within landscapes, identifying scales that are important for multiple taxonomic groups, such as the effort presented here, is very difficult. Different taxonomic groups and communities exhibit varied scales of response to environmental change (e.g., Wiens 1976, Wiens 1989). Because of these varied scales of responses, developing a concise model that is applicable to a wide variety of organisms may not appropriate or realistic. In addition, there is often great seasonality in the presence of taxa at sites, and the inability to conduct multiple site visits can restrict the number of taxa that are detected during surveys. The importance of local habitats to taxa can change significantly over time, and it is difficult in most studies to account for these changes. Although we were able to do this for terrestrial flora and vertbrates in this study, it was not possible to conduct multiple aquatic surveys. Delayed sampling at some sites compared to others due to weather can also lead to temporal discontinuity in data sets that can introduce random error in statistical analyses that confounds the results. Data resulting from additional visits to track seasonal changes in aquatic communities may have yielded much different results, although this can only be speculated. These are common, often unavoidable phenomena in any field study, although they warrant consideration in evaluating study results and provide some guidance for future study design.

Additional sections follow that discuss the results for aquatic and terrestrial vertebrate community analyses as well as the spatial analyses. Discussion points for terrestrial plant community and floristic surveys are included within the Results section above.

Aquatic Community Discussion

Extensive literature exists to document the importance of riparian structure as an influencing factor in stream ecosystems (Hynes 1975, Gregory et al. 1987, Gregory et al. 1991, Sweeney 1993, Peterjohn and Correll 1984, Lowrance et al. 1984, Behmer and Hawkins 1986, Gregory et al. 1987, Osborne and Kovacic 1993), although this pertains principally to smaller headwater streams. There is also considerable evidence to indicate the importance of multi-scale environmental properties of watersheds in shaping local aquatic communities (Leopold et al. 1964, Dunne and Leopold 1978, Vannote et al. 1980, Frissel et al. 1986, Steedman 1988, Schlosser 1991, Richards et al. 1996, Allan and Johnson 1997). Overall, it is generally accepted that conservation of aquatic communities requires considerations of environmental properties over multiple scales, although results for specific taxonomic groups can vary widely from study to study.

In this study, fish community attributes were not different among riparian forest buffer width classes, although this was not altogether surprising. Fish are highly mobile organisms, and they have the ability to move between stream reaches regardless of riparian properties. This fact coupled with patchy stream fish distribution both spatially and temporally (Angermeier and Smogor 1995) complicates the assumption that our samples reflected representative fish communities at sites based on a single sampling event. For example, when we were able to perform two fish sampling visits within the RR125-250 reach (reaches ~3 km apart), samples averaged 21 fish species/sites (RR125-250 had 19 and RR125-250r had 23), but the total # of fish species collected between the two sites was 27. Since four fish species were not common to both sites, our data supports patchy fish species distribution within these variably buffered streams. A reevaluation of the single site visit methodology may be necessary if it becomes important to document all fish species inhabiting riparian width class reaches.

Fish communities are widely regarded to shift from low diversity cool water assemblages in headwaters to higher diversity warmwater assemblages in larger rivers with open canopies (Huet 1954, Vannote et al. 1980). Stream temperatures are largely mediated by groundwater inputs and warming from penetrating sunlight rays. Riparian canopy can provide shading that moderates stream temperatures, although canopy shading of stream reaches was largely consistent among the riparian buffer classes. Given that shade and temperature regime were presumably comparable among sites, it is not surprising that local fish community measures were not significantly different among sites in response to these factors. This is also true for invertebrate communities that were responding not to forest canopy influences, but to instream habitats determined by a wide range of physical properties interacting over multiple spatial scales. Sedimentation regimes were also likely to be highly variable within and among buffer classes due to varied upstream land cover properties. Sedimentation regime can have a significant influence on fish communities (Karr and Schlosser 1977, Murphy et al. 1981, Hawkins et al. 1983, Rabeni and Smale 1995, Goforth 1999). This locally realized environmental property that is mediated by upstream processes might have also influenced fish communities to the extent that no significant differences could be detected among riparian buffer classes due to this extraneous source of variation.

Mussel community descriptors were also not different among the riparian forest buffer width classes. Strayer (1983) suggested that quaternary geology and watershed position were significant (although not necessarily the only) determinants of mussel species richness and abundance at sites. Instream habitat is also a significant driver for local unionid abundance and diversity, although this often occurs at the microhabitat scale, which can be highly unpredictable. Water quality is also of great importance to unionids, particularly those intolerant of degraded environmental conditions. Again, larger scale, upstream properties that drive water quality attributes may supercede local habitat availability, negating the positive influence of local riparian forest corridors. This is largely supported by the spatial analyses based on mussel data, which generally indicated the strongest correlations between mussel parameters and environmental properties of buffers over the largest landscape contexts used (i.e., U/S-2 and U/S-3).

Benthic species richness was the only aquatic community parameter that was nearly significantly different among the buffer width classes, although this reflected a trend towards declining BSR with increasing riparian corridor width. The reason for this is unclear and was considered to be somewhat counterintuitive to the expected results. Regardless, the marginal response of this taxonomic group to varied riparian buffer width classes was not surprising given that members of this group are especially dependent upon primary productivity mediated by riparian canopy despite the expected diminished influence of riparian canopy in larger streams (e.g., Vannote et al. 1981).

In this study, aquatic community measures were more responsive to channel types than riparian buffer widths. The occurrence of several characteristic stream channel types (i.e., shallow, swiftly flowing with cobble substrates; moderately incised with moderate current velocities and sandy-gravel substrates; and deeply incised with low current velocities and fine substrates) was not anticipated in the original study design. This variation in stream channel morphology is likely to be largely the product of mesoscale (i.e., 1-5 km^2) or larger patterns in quaternary geology. For example, the more deeply incised, "U"-shaped channel morphologies that are dominated by fine substrates are likely most often associated with fine textured glacial till or lacustrine clay and silt surface geology types (e.g., Richards et al. 1996). Allan et al. (1997) also reported that local riparian attributes were poor predictors of aquatic habitat quality and ecological integrity, and that channel properties shaped by regional factors, such as changes in land cover, were more significant driving factors for aquatic communities. While stream channel morphology and substrate composition are not solely driven by local surface geology, there is little question that surface geology has strong influence on local substrate and biota distributions. In one example, Badra and Goforth (1999) documented the presence of suitable substrates and the occurrence of a significant source population for the Federally-listed as endangered clubshell mussel, *Pleurobema clava*, in a portion of a watershed in which only a small finger of glacial outwash sand and gravel intersected the channel. Substrates of channels up and downstream from the source population were dominated by clays with a veneer of cobble and gravel with only a few sparsely distributed pockets of suitable habitat. Yet, the portion of the main stem that was intersected by the glacial outwash was characterized by mixed substrates with higher groundwater inputs. Other studies have described similar patterns in substrate and mussel species distribution relative to quaternary geology (e.g., Strayer 1983, Kopplin 2002). However, data based on the currently available 1:500,000 scale surface geology maps were found to be too coarse to demonstrate such patterning in our initial efforts to detect associations among local channel types, biota and quaternary geology patterns in this study.

Discrepancies in the measurement of ecological and biological integrity for streams characterized by varied channel properties likely underestimated the biodiversity value of streams in riparian corridors with moderately and deeply incised channels, especially within the context of wider riparian cooridors. A long-lived paradigm in stream ecology and the basis for most IBIs is the general expectation that streams characterized by moderately to highly incised channels, fine substrates and moderate to slow current velocities reflect degraded environmental conditions compared to the natural or pristine state. Habitat availability at such sites is therefore not generally considered to be optimal for high quality aquatic communities. Given the sizable forested floodplains and repeated occurrences of similar channel types among basins, the channel types observed in this study were likely to be characteristic habitats of the landscape rather than drastically altered examples of what were once shallow, swiftly-flowing, rocky streams. The long-term saturation of these floodplains throughout the year makes them poor to marginal for agricultural uses. Thus, they remain as broad riparian corridors that may have been harvested for timber historically, but have remained largely intact. There is little doubt that the supply of fine substrates to these systems and turbidity levels have increased due to landscape land cover changes in upstream areas. Despite these landscape influences, these streams are arguably good representatives of diagnostic rivers for this landscape. Their value is difficult to justify given that they do not fit the shallow-rocky-fast model that dominates current views of what streams should look like in Michigan. At the same time, the communities associated with these systems are comprised of taxa that are generally tolerant of degraded environmental conditions, so threats to such taxa can be considered insignificant next to threats to more intolerant taxa in other systems. Regardless, these deep-slow-silty streams are an important resource, and criteria for evaluating their integrity needs to be developed in order to identify excellent quality examples for conservation.

Based on this assessment, sampled streams with moderately to deeply incised channels did not necessarily indicate low aquatic ecological integrity in this study. They may have reflected some of the least modified systems sampled, at least in terms of proximate disturbance. However, criteria for identifying high quality examples of such sites have not been developed. The criteria used for assessing streams in this study were better suited to shallow, fast-flowing, clear, rocky-bottomed streams and likely undervalued the representative biodiversity value of sites with moderately to deeply incised channel morphologies. Therefore, there is great need for the development of criteria and assessment techniques for streams other than shallow, fast flowing ecotypes. Given the availability of such criteria and techniques, we expect aquatic components of riparian biodiversity to better fit the model of increasing biodiversity reserve potential (i.e., both aquatic a terrestrial) with increased riparian corridor width.

One issue for developing biological and ecological criteria for moderately incised and deeply incised streams is that taxa that would naturally comprise communities at these sites are typically considered to be tolerant of physico-chemical variables consistent with environmental degradation in shallow stream systems (e.g., Barbour et al. 1999). Without the development of indicators or biocriteria for these types of systems, their biodiversity value can only be speculated or derived based on protocols developed for dissimilar stream ecotypes (i.e., shallow, fast flowing with large substrates). In a landscape where streams with shallow channels are dominant, the approach used in this study would be more appropriate. However, for southern Lower Michigan, which is comprised of multiple stream channel types, the methods used in this study to assign ecological/biological integrity values were not effective in describing biodiversity value of the various stream types. In order for a remotely sensed riparian approach to have greater potential success in determining aquatic biodiversity value in such a landscape, comparable biodiversity assessment methods have to be developed for the respective channel types. Such assessment techniques would also have great significance in better describing the representative range of biological resources occurring within a landscape.

The multiple channel types observed among sites necessitated the inclusion of channel type as a potential driver of stream community/ecological measures among sites. Channel type was not identified as a factor for analysis in the original experimental design, although it became clear after the first year of study that channel properties varied among study sites independent of riparian corridor width classes. It was not surprising that fish and mussel species richness was statistically higher for shallow and moderately incised channels compared to deeply incised channels. Mollusk experts generally agree that native mussel communities are generally intolerant of stream conditions marked by slow current velocity, high turbidity and dominance of fine substrates (NNMCC 1998). Habitat diversity in slow, deep streams with fine substrates is generally low, and other physico-chemical attributes, such as oxygen concentration and temperature regime are appropriate for a narrower range of both fish and unionid species. The greater species richness observed for both fish and mussels in shallow and moderately incised channels may reflect higher detection rates of these taxa in shallower, less turbid streams. However, the substrates generally occurring at the deeply incised sites were not appropriate for many of the species that were detected at shallower sites. Thus, low detection was likely not an issue and the observed patterns likely reflected actual differences in community structure.

Most of the fish and mussel community parameters indicated that higher levels of biological integrity and aquatic biodiversity value (e.g., RAIF, FIBI, RAIU) were associated with shallow and moderately incised stream channels compared to the streams with deeply incised channels. Measures that indicate high biotic tolerance to environmental conditions of sites, including RATU and MBTI, were significantly higher for the deeply incised streams. As discussed previously, these indices are generally developed to assess the condition of streams characterized by shallow, rocky stream beds and moderate to fast stream current velocities. Given that biodiversity criteria have not been nearly as well developed for deeply incised streams, the channel analysis can be interpreted as reflecting differences in community structure associated with the various channel types rather than low vs. high relative biodiversity value. Additional assessment of these systems that would provide evidence to suggest that the deep-slow-fine streams were in fact degraded would support the argument that the analysis indicates higher biodiversity value for the shallower streams. However, demonstrating that channel type is an important determinant of stream community structure with respect to fish and mussels has great merit and will contribute to the development of stream classification to identify examples of significant, representative ecotypes within landscapes.

Species richness, abundance and density has been reported to decline in response to elevated sediment loads (Cordone and Kelly 1961, Gibbons and Salo 1973, Karr and Schlosser 1978, Lenat et al. 1981, Murphy et al. 1981, Hawkins et al. 1982). Benthic invertebrates, in particular, have been reported to decline in response to high sediment regimes (Lenat et al. 1981, Hawkins et al. 1982, Cobb and Flannagan 1990, Flannagan et al. 1990, Cobb et al. 1992). However, no benthic invertebrate community measures were different among the channel classes despite the prevalence of fine sediments at sites with deeply incised channels. Species richness is an arguably variable descriptor of biological integrity that is not sensitive to the character of the species that comprise the richness of the community being observed. Two ecosystems can have very similar species richness measures, although the species comprising the communities of each site may be variably adapted to the ecological conditions of each site. Community composition is likely to be sensitive to channel morphology, although the number of species that are adapted to the varied channel types may not be significantly different, especially in a landscape where deep-slow-silty streams were a prominent feature of pre-European settlement landscapes. In streams, local habitat is certainly an important factor that drives distribution of taxa, but water quality is important as well. Good quality physical habitat is insufficient to support high biodiversity if water chemistry has been compromised at some point upstream, thus influencing communities in downstream areas.

It is not surprising that MSR and FSR were highly correlated given the intricate relationship between freshwater unionids and their fish hosts. This correlation between mussel and fish community diversity has been documented on the scale of entire drainage basins (Watters 1992), and may possibly be explained by the life cycle of most unionids (e.g., use of fish hosts by mussel glochidia, the parasitic larval stage). Since different mussel species require very specific host fish species for propagation, it is logical to assume that an increase in the numbers of fish species present will increase the possibility of greater mussel species recruitment. There is often little overlap in fish host species among unionids occupying the same reach. High MSR therefore relies on high FSR to enable mussels within a highly diverse community to successfully reproduce and persist at a site. Densities of host fish communities have positively correlated with increased densities of certain mussels in streams of Alabama (Haag and Warren, unpublished data). However, this pattern was marginal within our study streams. Mussel density measurements are usually performed with quantitative methods (Strayer et al. 1996), while our methods took a qualitative approach. It is possible that relating the MCPUE estimates we calculated to the FCPUE is a gross under-representation of the actual mussel densities at the survey sites.

Terrestrial Vertebrate Discussion

The eight frog and toad species observed during this study represent 73% of the fauna (14 species total) that is known to occur within the region surveyed. Based on general habitat requirements and species' known ranges within the state (Harding 1997), the forested floodplain, or riparian, habitat surveyed as part of this study has the potential to support four salamander species, six frog and toad species, six snake species and six turtle species, totaling 22 herptile species. This total comprises 42% of the 53 amphibian and reptile species found in Michigan. Thus, forested riparian areas could provide habitat for a relatively high percentage of herptile species in the state. This study documented only 15 (68%) of the 22 potential species that could occur in forested riparian areas.

The two most common species were the wood frog and American toad. Wood frogs prefer moist wooded habitats and typically inhabit water only during a short (six to 14 days) breeding season (Harding 1997). Vernal ponds, floodings, wooded swamps and quiet stream backwaters are all used by wood frogs for breeding. American toads utilize a wide variety of habitats, ranging from open woodlands, prairies and marshes to residential yards, parks and agricultural areas (Harding 1997). They prefer to breed in shallow, temporary waters with sparse to moderate amounts of emergent and submergent vegetation, including flooded fields, ditches, stock ponds, open marshes and backwaters of slow-moving streams. Species that have potential to occur in forested riparian habitat but were not documented during this study may have been absent due to the lack of specific habitat requirements at the community and/or microhabitat scales at the study sites (see Burbrink et al. 1998). Alternatively, these species may have eluded detection due to insufficient sampling or the secretive and/or cryptic nature of the species.

A few species typically associated within non-forested riparian habitat were found during this study, likely due to adjacent habitat. One such species was the northern leopard frog, which is typically associated with marshes, meadows and grassy edges of ponds, lakes and streams. This species was found at the

GR<125 site and incidentally at the KZ250-500 site, (year 1) likely due to the presence of prairie fen habitat and open grassy areas adjacent to the forested riparian zones at these sites, respectively. Similarly, the Blanding's turtle, the only rare herptile species documented during the study, can occur in river backwaters and embayments, but is commonly associated with shallow, vegetated waters such as ponds, marshes and wet prairies. This species was found at the GR<125 site, probably due to the presence of the prairie fen adjacent to the forested riparian area.

Results from the ANOVAs suggested that species richness and relative abundance of frogs were somewhat affected by riparian corridor width, although levels of response often varied among the channel types associated with these corridors. The habitat correlation analyses also provide evidence that amphibian and reptile communities may be related to other local or site-level habitat factors such as CTV, BA and tree DBH. These site-level habitat conditions are not necessarily associated with width of the riparian habitat. Burbrink et al. (1998) documented similar results in a study that looked at species richness of amphibians and reptiles utilizing a riparian corridor of different widths in southern Illinois. They found that species richness was not significantly affected by width of the riparian corridor, and that the habitat heterogeneity needed to provide all the life cycle requirements of amphibians and reptiles was not associated with riparian width. Our results suggest that while species richness may not be greater in wider corridors, the habitat that is available for resident species is greater and supports higher relative abundance of these taxa.

Finally, although the use of multiple survey methodologies was fairly successful in documenting the suite of amphibian and reptile species that inhabited the study areas, the addition of incidental species indicates that surveys failed to document the full range of species that utilized these areas. Also, although survey methodologies were fairly good at detecting species, relative abundance estimates were fairly low compared to other studies (e.g., Karns 1986). This may be due to different herp densities associated with different habitats, and low herp densities may characterize forested floodplain or riparian habitat. Low relative abundance estimates also may be an artifact of limited sampling. Since some herps can be secretive and difficult to find, and since survey results can vary significantly with weather and survey conditions, strong likelihood exists that extended or multiple trapping periods and multiple visits to each site for frog call and visual surveys would have yielded more herp species and higher numbers. Other studies also have found that multiple methodologies and long-term sampling efforts are needed to capture or document the full range of herp species and adequately estimate the abundance of herps that occur in an area (Campbell and Christman 1982, Karns 1986, Corn 1994, Greenberg et al. 1994). Therefore, results from this year's study should be viewed as baseline data, and additional work is needed to continue to elucidate amphibian and reptile use of riparian ecosystems.

To gain a better understanding of community composition and the factors influencing avian use of riparian ecosystems the focus and scope of this study was modified in order to acquire better analytical data. As a result, the migration portion of the study was eliminated and concentration focused on breeding bird surveys. Increasing sample size and conducting multiple visits at each site assisted in providing a better measure of the avian community composition and abundance during the breeding season. However, the data is still somewhat limited in its usefulness in terms of gaining insight into factors that influence bird use in riparian ecosystems. This is due to a differing number of point count stations per site. Several riparian sites in the study were not of adequate length to incorporate all three point count stations with 200-m separation distances between them. Because of this three sites (RC<125, SH<125, and MR<250) contained only two stations, and one site (PR<125) contained only one station. This uneven number of stations among the 18 sites lead to an uneven amount of time spent at the sites. As a result, the possibility exists that these four sites are underrepresented both in species richness and in overall bird abundance.

During the 2001 breeding bird survey a total of 60 species were observed or heard. This includes those species outside the 50-m point count radius as well as incidental observations by other researchers on separate monitoring surveys. No listed or special concern species were identified during the survey. This result is not unexpected for the breeding season, except for two possible omissions. Both prothonotary warbler and Louisiana waterthrush are found in floodplain forested habitats. However, densities for both species are low in Michigan and their ranges are more centrally located in the southwest portion of the state-outside this study area (Brewer et al. 1991).

Mean species richness and mean bird abundance were highest for riparian areas with C-type channels and in riparian widths >250m. Type C channels are slow-moving, meandering river systems with broad floodplains. Riparian widths of >250m are the widest strips of forested habitat used in the study. These high means indicate that more bird species, as well as more individual birds, used wide forested floodplain habitats with frequent river overflow.

Spatial Analysis Discussion

Land cover properties quantified over local and catchment scales influence stream communities and habitats (Corkum 1989, Corkum 1991, Richards and Minshall 1992, Richards and Host 1994, Lammert 1995, Allan and Johnson 1997, Allan et al. 1997, Richards et al. 1997). Correlation analyses of reach specific habitat and community measures with buffer land cover properties quantified over multiple scales presented herein provide additional support for the argument that local stream ecology is driven by multispatial environmental properties. In addition, associations between local measures of stream integrity and land cover types can also change within the context of relatively subtle changes in landscape scale (e.g., among the upstream contexts used for this study). These analyses suggest that characterization of riparian communities and identification of significant biodiversity refugia in fragmented landscapes cannot rely solely on local riparian zone condition, but must also include upstream, and possibly downstream, contexts for effective conservation.

TASR was most highly correlated with the spatial extent of forests (negatively associated) and agriculture (positively associated) of mid-sized buffers in the local landscape context. This was surprising given that aquatic species richness is generally considered to be dimininshed in close proximity to agricultural lands (Allan et al. 1997). However, the diversity in channel morpologies observed during this study, and the tendency for deeper, siltier channels to be associated with extensive riparian forests may explain this pattern. Many taxa are not tolerant of habitat conditions associated with these channels, and species richness is often lower as a consequence. This appeared to be the case in the present study.

Fish community measures were generally not correlated with land cover properties of any landscape context. This may reflect the high mobility of fish species and their reliance upon a wide range of aquatic habitats to complete their life history needs (Gowan et al. 1994, Goforth and Foltz 1998). As mentioned previously, studies to determine biodiversity patterns in fish communities would likely be best served by a multiple-visit survey design that was beyond the scope of this study. Other studies have reported contrasting results indicating that fish IBI scores could be predicted by upstream (Steedman 1988 and Allan et al. 1997) or local land cover properties (Goforth 1999). Goforth (1999) reported that RAIF scores were correlated with upstream land cover properties, presumably because of the role that upstream physical processes play in determining downstream water quality parameters important for intolerant taxa. However, RAIF values were not correlated with buffer land cover properties in this study.

Local-scale responses of benthic communities to changes in riparian structure have been richly documented (Hawkins et al. 1982, Gregory et al. 1987, Gregory et al. 1991, Sweeney 1993, Goforth 1999, and others), although BNSR measures in this study were consistently associated with larger landscape contexts (i.e., U/S-1). Such results are consistent with other studies reporting relationships between benthic communities and landscape properties (Richards et al. 1993, Richards and Host 1994, Richards et al. 1997, Goforth 1999). BNSR values were negatively correlated with forest components of U/S-1 buffer areas and were positively correlated with the proportion of U/S-1 buffer areas encompassed by agricultural land covers. This was unexpected given that BNSR values are usually expected to generally decrease under environmental stress. Agricultural land covers in upstream areas would presumably contribute to lower water quality and lower BNSR values in downstream areas, although this was not the case. Aquatic insects typically exhibit "drifting" behavior, in which they periodically release from stream substrates and are swept downstream by water flow, later settling in a new location. The correlations observed may reflect different levels of drifting activity by benthic invertebrates in response to changes in nearstream land cover. Benthos inhabiting streams flowing through fragmented landscapes may preferentially drift from reaches surrounded by agriculture and settle (and perhaps aggregate) in reaches with forest cover that essentially provide islands of preferred habitat. Greater prevalence of agriculture upstream may lead to increased BNSR downstream while greater prevalence of forest land covers upstream may enable intolerant benthos to be more sparsely distributed among upstream areas.

Mussel species richness and distribution are associated with increasing stream size (Strayer 1983, van der Schalie 1938) and surficial geology, presumably in response to instream ecological factors related to these properties (e.g., current velocity, substrates, etc., Strayer 1983). Changes in land cover can influence such factors, and appeared to do so in this study based on correlations between mussel community measures and environmental properties of buffers in the U/S-2 and U/S-3 landscape contexts. Mussel densities within stream reaches can vary highly depending on the availability of microhabitats (e.g., substratum and current velocity), although this habitat availabilty is heavily dependent upon environmental properties interacting over multiple scales. Thus, the transects used provided an overall estimate of mussel abundance and richness for the site without regard to microhabitat type. Substrate composition heavily influences mussel distribution and is often patchily distributed throughout local stream reaches. This patchy distribution of microhabitats is difficult and perhaps impossible to predict based on adjacent and upstream land cover properties. The RAIU is a essentially a surrogate for mussel community tolerance to degraded environmental conditions such as increased turbidity, high nutrient loads, disturbed hydrologic regime and increased sedimentation. These are watershed processes mediated primarily by larger scale environmental properties (Dunne and Leopold 1978, Omernik et al 1981, Hildrew and Giller 1994, Roth et al. 1996, Allan et al. 1997). The positive correlation observed between site RAIU values and forest components of the larger U/S-2 buffer areas likely reflects the ability of extensive forested areas in riparian corridors to ameliorate landscape inputs of eroded soils and nutrients.

Terrestrial vertebrate community parameters were not correlated with land cover properties of buffers within any landscape contexts. This may be due, in part, to the necessarily smaller sample sizes for these groups resulting from a change in taxonomnic focus during year two of the study. Alternatively, it may provide additional evidence to support the conclusion by Burbrink et al. (1998) that herpetofauna in the Midwest are not sensive to larger scale riparian and landscape environmental properties, and are, instead, more responsive to the availability of microhabitat mediated by smaller scale processes.

Floristic measures were variably associated with buffer land cover properties in the spatial analysis. The patterns that emerged from these analyses support the idea that native plant species richness and community integrity are negatively impacted by increasing levels of agriculture and other land developments over multiple scales. This is not surpring given that anthropogenic land uses generally alter native habitats to the extent that they are no longer able to support native taxa or become increasingly susceptible to invasion by adventive species. Protection of native flora and vegetation therefore will rely on a multi-scale land stewardship approach to insure the long term viability of native terrestrial communities within fragmented landscapes.

CONCLUSION

The overall results of this study did not wholly support the sole use of riparian corridor width and contiguity as guiding factors for identifying riparian biodiversity potential in fragmented landscapes of southern Lower Michigan. Further study that includes appropriate criteria for determining the integrity of streams with varied channel characteristics may lead to more definitive models of riparian biodiversity that do provide greater evidence for the use of riparian characteristics as broad scale criteria for prioritizing conservation targets within landscapes. While using broad generalizations to guide management of natural resources should be tempered with great caution, models do provide a useful means for “triage planning” across large landscape areas. In this case, we can expect that, in general terms, conservation actions aimed at wider, more contiguous riparian corridors will yield the greatest benefits in terms of enhancing the long-term viability of native biodiversity within fragmented landscapes, at least with respect to plant taxa and some terrestrial vertebrates. Further model development and verification is warranted and may provide the opportunity to refine the landscape scale conservation models by considering alternative landscape contexts at different scales that may serve as more effective spatial units for conserving a broader range of taxa. In addition, further testing of the model may indicate that it has applicability beyond southern Lower Michigan and can be used as a management tool across multiple regions, both within the context of North America and globally.

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APPENDICES

Appendix I. Fish species sample data (#individuals/site), species group associations (SPA, Zorn et al. 1998), tolerance values (TV) and trophic status (TR) for river reaches associated with riparian corridors sampled in 2000 and 2001. Rivers include the Grand (GR), Kalamazoo (KZ), Raisin (RR), St. Joseph (SJ) Rivers, Shiawassee (SH), Looking Glass (LG), Thornapple (TR), Red Cedar (RC), Pine (PR), Sycamore Creek (SC), Maple (MR) Rivers, and riparian buffer width classes include <125m (125), 125-250m (250) and 250-500m (500). (E) indicates a state-listed as endangered species.

				Sample Site								
Fish Species	**SPA**	**TV**	**TR**	**GR125**	**GR250**	**GR500**	**KZ125**	**KZ250**	**KZ500**	**RR125**	**RR250**	**RR500**
Central stoneroller	**1**	**m**	**h**					**2**		**1**	**1**	
Common Shiner	**1**	**m**	**i**	**13**			**2**	**17**	**6**		**18**	**15**
Redfin Shiner	**1**	**m**	**i**	**1**			**1**		**2**	**5**	**7**	**7**
Bluntnose Minnow	**1**	**t**	**o**	**1**		**1**	**9**	**7**	**12**	**3**	**8**	**5**
Creek Chub	**1**	**t**	**i**	**6**			**37**	**1**	**5**	**8**	**8**	**1**
Johnny Darter	**1**	**m**	**i**	**3**	**7**	**3**	**21**	**1**	**9**	**10**	**13**	**2**
Green Sunfish hybrid	**2**	**t**	**i**			**1**	**1**	**1**				
Bluegill	**2**	**t**	**i**	**2**		**2**	**1**	**1**			**7**	**4**
Brook Stickelback	**2**	**m**	**i**									
Blacknose Dace	**3**	**t**	**i**									
Mottled Sculpin	**3**	**m**	**i**						**2**	**3**	**1**	
Fathead Minnow	**4**	**t**	**o**				**8**					
White Sucker	**4**	**t**	**o**	**6**		**3**	**6**	**1**	**5**	**1**	**4**	**6**
Rainbow Trout	**6**	**i**	**i**									
Yellow Bullhead	**8**	**t**	**i**									
Green Sunfish	**8**	**t**	**i**	**8**	**6**	**2**		**1**		**3**		
Golden Shiner	**9**	**t**	**o**									
Blackside Darter	**9**	**m**	**i**	**2**			**6**			**3**		**2**
Iowa Darter	**9**	**m**	**i**									
Pumpkinseed	**9**	**m**	**i**									
Warmouth	**9**	**m**	**p**									
Northern Pike	**9**	**m**	**p**									
Pirate Perch	**9**	**m**	**i**									
Bowfin	**9**	**m**	**p**	**1**	**1**							
Central Mudminnow	**9**	**t**	**o**	**6**	**2**	**1**			**1**			
Walleye	**10**	**m**	**p**			**1**						
Black Crappie	**10**	**m**	**i**									
Common carp	**10**	**t**	**o**	**1**			**1**	**1**		**1**		**1**
Spotfin Shiner	**12**	**m**	**i**			**3**				**9**	**6**	**15**
Sand Shiner	**12**	**m**	**i**									
Logperch	**12**	**m**	**i**									
Shorthead Redhorse	**12**	**m**	**i**						**1**			
Channel Catfish	**12**	**m**	**p**									
Hornyhead Chub	**13**	**i**	**i**	**6**			**2**	**7**	**4**	**1**		**23**
Grass Pickerel	**13**	**m**	**p**	**1**	**2**	**1**					**2**	
Rock Bass >5 inches	**14**	**i**	**i**	**1**				**3**	**5**		**2**	
Rock Bass <5 inches	**14**	**m**	**i**				**3**	**3**	**14**	**1**	**1**	
Rainbow Darter	**14**	**i**	**i**	**26**			**58**	**7**	**16**		**1**	**4**
Longear Sunfish	**14**	**i**	**i**									
Largemouth Bass	**14**	**t**	**p**	**2**	**2**	**14**						**1**
Striped Shiner	**15**	**m**	**i**	**1**			**20**	**26**	**18**		**4**	**13**
Northern Hogsucker	**15**	**i**	**i**	**2**		**2**	**1**	**6**	**1**	**5**	**6**	**49**
River Chub	**15**	**i**	**i**				**3**	**3**			**3**	**52**
Greenside Darter	**15**	**m**	**i**	**2**						**9**	**6**	**7**
Smallmouth Bass	**15**	**m**	**i**				**2**	**12**	**1**	**1**	**2**	**3**
Black Redhorse	**15**	**i**	**i**							**3**		
Stonecat	**15**	**i**	**i**				**3**	**1**				
Rosyface Shiner	**16**	**i**	**i**				**19**		**35**		**4**	**13**
Yellow Perch	**16**	**m**	**p**									
Spottail Shiner	**17**	**i**	**i**			**1**				**1**		
Golden Redhorse	**17**	**m**	**i**								**1**	
Silver Shiner (E)	**18**	**i**	**i**								**10**	
Silverjaw Minnow	**19**	**m**	**i**									**3**
Amer. Brook Lamprey	**20**	**i**	**f**									
Total # Individuals				**91**	**20**	**35**	**204**	**101**	**137**	**68**	**115**	**226**
Total # Species				**20**	**6**	**13**	**20**	**19**	**17**	**18**	**22**	**20**
CPUE				**1.6**	**0.5**	**0.8**	**4.2**	**2.5**	**3**	**1.3**	**1.6**	**4.1**

Appendix I. *Cont.*

Fish Species	SPA	TV	TR	Sample Site								
				SJ125	SJ250	SJ500	RC125	RC250	SC500	LG125	LG250	TR250
Central stonerolle	1	m	h		2							
Common Shine	1	m	i	2	17	6					18	3
Redfin Shine	1	m	i	1		2	3				4	
Bluntnose Minnow	1	t	o	9	7	12	11			4	56	
Creek Chub	1	t	i	37	1	5	1	4	1		10	50
Johnny Darte	1	m	i	21	1	9	5	13	40	9	11	1
Green Sunfish hybri	2	t	i	1	1		2			4		
Bluegill	2	t	i	1	1		16	5				1
Brook Stickelbacl	2	m	i					1	11			10
Blacknose Dace	3	t	i								3	
Mottled Sculpin	3	m	i			2						
Fathead Minnow	4	t	o	8								
White Sucke	4	t	o	6	1	5	9		14	5	24	12
Rainbow Trou	6	i	i				1					
Yellow Bullhead	8	t	i							3		
Green Sunfis	8	t	i		1		2		14	24	17	3
Golden Shine	9	t	o									
Blackside Darte	9	m	i	6			4	3	5		3	3
Iowa Darte	9	m	i							2	1	
Pumpkinseed	9	m	i							1		
Warmouth	9	m	p									
Northern Pik	9	m	p									
Pirate Perch	9	m	i							2		
Bowfin	9	m	p									
Central Mudminnov	9	t	o			1	2	3		1		3
Walleye	10	m	p									
Black Crappie	10	m	i									
Common carp	10	t	o	1	1			1	1	4	1	1
Spotfin Shine	12	m	i				1			3	17	
Sand Shine	12	m	i				2				2	
Logperch	12	m	i									
Shorthead Redhors	12	m	i			1						
Channel Catfis	12	m	p									
Hornyhead Chul	13	i	i	2	7	4					9	2
Grass Pickere	13	m	p				1			4		
Rock Bass >5 inches	14	i	i		3	5	10	1	1	7	13	1
Rock Bass <5 inches	14	m	i	3	3	14	5			14	11	
Rainbow Darte	14	i	i	58	7	16	4	22	6		11	1
Longear Sunfis	14	i	i							2		
Largemouth Bas	14	t	p				1			2	1	
Striped Shine	15	m	i	20	26	18						
Northern Hogsucke	15	i	i	1	6	1		4				
River Chub	15	i	i	3	3			3			6	1
Greenside Darte	15	m	i				2					
Smallmouth Bas	15	m	i	2	12	1	1	1			2	
Black Redhors	15	i	i									
Stonecat	15	i	i	3	1							
Rosyface Shine	16	i	i	19		35	5	2			5	1
Yellow Perch	16	m	p									
Spottail Shine	17	i	i									
Golden Redhors	17	m	i									
Silver Shiner (E	18	i	i									
Silverjaw Minnov	19	m	i									
Amer. Brook Lampre	20	i	f									
Total # Individuals				204	101	137	88	63	93	91	225	93
Total # Species				20	23	25	21	13	9	17	21	15
CPUE				2.1	1.5	1.3	1.8	1.4	2.1	1.4	5.2	1.2

Appendix I. *Cont.*

				Sample Site							
Fish Species	**SPA**	**TV**	**TR**	**PR125**	**PR250**	**PR500**	**SH125**	**SH250**	**SH500**	**MR125**	**MR250**	**MR500**
Central stonerolle	1	m	h	2				1			2	
Common Shine	1	m	i	7	31	14		3	2	4	67	1
Redfin Shine	1	m	i	10	5	1	4	1				11
Bluntnose Minnow	1	t	o	101	7	1	11	6		3	29	3
Creek Chub	1	t	i	5	19	10	35	4	1		21	
Johnny Darte	1	m	i	3	17	1	6	2	2	1	5	10
Green Sunfish hybri	2	t	i			1	2	2		1		1
Bluegill	2	t	i	2	1	1	1	1	1			13
Brook Stickelbac	2	m	i		2	4			5			
Blacknose Dac	3	t	i		8						11	
Mottled Sculpin	3	m	i									
Fathead Minnow	4	t	o									
White Sucke	4	t	o	5	14	1		18	3	11	4	
Rainbow Trou	6	i	i									
Yellow Bullhead	8	t	i								3	
Green Sunfis	8	t	i	4	3	2	1	17	9	4	1	1
Golden Shine	9	t	o		1							
Blackside Darte	9	m	i		4	4	3		2	3	1	
Iowa Darte	9	m	i									
Pumpkinsee	9	m	i							3		5
Warmout	9	m	p							1		
Northern Pik	9	m	p	1								
Pirate Perch	9	m	i									
Bowfin	9	m	p									
Central Mudminnov	9	t	o		2	1	1	2	31	1	1	
Walleye	10	m	p									
Black Crappi	10	m	i				1					
Common car	10	t	o	1						1	1	1
Spotfin Shine	12	m	i	34			8	5		12		
Sand Shine	12	m	i	7			14					
Logperch	12	m	i					1		1		
Shorthead Redhors	12	m	i						2			
Channel Catfis	12	m	p							1		
Hornyhead Chu	13	i	i	3	7	2		2	5		11	
Grass Pickere	13	m	p						2	1		2
Rock Bass >5 inche	14	i	i	2		1	11	9	2	1	4	
Rock Bass <5 inche	14	m	i	3			16	10	2	12	5	2
Rainbow Darte	14	i	i	1	2	1		7			39	
Longear Sunfis	14	i	i					5				
Largemouth Bas	14	t	p	2			1		1			1
Striped Shine	15	m	i									
Northern Hogsucke	15	i	i		4	1		3	1	4	14	
River Chu	15	i	i	3			20	5				
Greenside Darte	15	m	i	2								
Smallmouth Bas	15	m	i	1	1	1	1	1				1
Black Redhors	15	i	i		1	3	1	3	2	2	2	
Stonecat	15	i	i	3			1	1				1
Rosyface Shine	16	i	i	1		1	4	2		2	10	
Yellow Perch	16	m	p					1				
Spottail Shine	17	i	i									
Golden Redhors	17	m	i	1			3	2	2	1	2	
Silver Shiner (E	18	i	i									
Silverjaw Minnov	19	m	i									
Amer. Brook Lampre	20	i	f		2	5			1			
Total # Individuals				204	131	56	145	114	76	70	233	53
Total # Species				24	19	20	21	26	19	21	20	14
CPUE				1.7	2.1	0.6	1.8	1.3	1.1	2	2.9	0.9

Appendix II. Mussel species data for river reaches associated with riparian corridors sampled in 2000 and 2001. Rivers include the Grand (GR), Kalamazoo (KZ), Raisin (RR), St. Joseph (SJ) Rivers, Shiawassee (SH), Looking Glass (LG), Thornapple (TR), Red Cedar (RC), Pine (PR), Sycamore Creek (SC), Maple (MR) Rivers, and riparian buffer width classes include <125m (125), 125-250m (250) and 250-500m (500). Tolerance values (TV) range from 0-4, with 4 reflecting species with the greatest toltertance to degraded environmental conditions. State of Michigan listing status is provided, including state-listed as threatened (T) and state-listed as special concern (SC). Asterix (*) reflect sites at which a given species was only recorded from dead shells.

		Sample Site								
Mussel Species	**TV**	**GR125**	**GR250**	**GR500**	**KZ125**	**KZ250**	**KZ500**	**RR125**	**RR250**	**RR500**
Actinonaias ligamentina **(Mucket)**	1	4		*	1	*	1	2	2	12
Amblema plicata **(Three-ridge)**	3	1		1						
Alasmidonta marginata **SC (Elktoe)**	2							5		4
Alasmidonta viridis **SC (Slippershell)**	2				1		4			
Anodonta grandis **(Giant Floater)**	4							1		
Anodonta imbecilis **(Paper pondshell)**	2									
Anodontoides ferussacianus **(Cylindrical papershell)**	2									
Cyclonaias tuberculata **SC (Purple Wartyback)**	2								93	
Elliptio dilatata **(Spike)**	2	6		*	248	*	44		61	2
Epioblasma triquetra **T (Snuffbox)**	0									
Fusconaia flava **(Wabash Pigtoe)**	2	*		*	*	1	1	*	190	7
Lampsilis fasciola **T (Wavy-rayed Lampmussel)**	2						2		11	1
Lampsilis ventricosa **(Pocketbook)**	2	1			9	1		2	30	15
Lampsilis siliquoidea **(Fatmucket)**	4			4	1			11		1
Lasmigona compressa **(Creek Heelsplitter)**	3				4			5		14
Lasmigona complanata **(White Heelsplitter)**	4									
Lasmigona costata **(Fluted Shell)**	3				*	*		1	*	1
Leptodea fragilis **(Pink Heelsplitter)**	3									
Ligumia recta **(Black Sandshell)**	2									
Pleurobema coccinium **SC (Round Pigtoe)**	2	9			74	1	6		31	1
Ptychobranchus fasciolaris **(Kidneyshell)**	1									2
Quadrula pustulosa **(Pimpleback)**	3									
Strophitus undulatus **(Squawfoot)**	4			1				1	1	
Venustaconcha ellipsiformis **SC (Ellipse)**	1				2		*		1	
Vilosa iris **SC (Rainbow)**	1	3		*	80	2	46	*	1	
Total # Individuals/Site		24	0	6	420	5	104	28	421	60
Total Native Species/Site		6	0	3	9	4	7	8	10	11

Appendix II. *Cont.*

Mussel Species	TV	Sample Site									
		SJ125	SJ250	SJ500	RC250	RC125	SC500	TR250	LG250	LG125
Actinonaias ligamentina **(Mucket)**	**1**	**7**	**55**	**4**					**3**	
Amblema plicata **(Three-ridge)**	**3**									
Alasmidonta marginata **[SC] (Elktoe)**	**2**			**2**		**7**		*****	**1**	**2**
Alasmidonta viridis **[SC] (Slippershell)**	**2**	*****						*****	**4**	
Anodonta grandis **(Giant Floater)**	**4**				**1**	**2**		*****	**1**	**2**
Anodonta imbecilis **(Paper pondshell)**	**2**									
Anodontoides ferussacianus **(Cylindrical papershell)**	**2**				*****				**2**	
Cyclonaias tuberculata **[SC] (Purple Wartyback)**	**2**									
Elliptio dilatata **(Spike)**	**2**	**35**	**13**	**28**	**59**	**7**	**29**	**107**	**9**	**1**
Epioblasma triquetra **[T] (Snuffbox)**	**0**									
Fusconaia flava **(Wabash Pigtoe)**	**2**		**1**	**1**	**6**	**8**	**1**	**1**	**8**	**2**
Lampsilis fasciola **[T] (Wavy-rayed Lampmussel)**	**2**									
Lampsilis ventricosa **(Pocketbook)**	**2**	**6**	**5**	**6**	**5**	**3**			**10**	**1**
Lampsilis siliquoidea **(Fatmucket)**	**4**		**4**	**1**		**7**		**8**	**3**	**6**
Lasmigona compressa **(Creek Heelsplitter)**	**3**		**2**							
Lasmigona complanata **(White Heelsplitter)**	**4**					**3**				
Lasmigona costata **(Fluted Shell)**	**3**	**3**	**2**	**4**	**3**	**11**	**1**		**6**	**4**
Leptodea fragilis **(Pink Heelsplitter)**	**3**									
Ligumia recta **(Black Sandshell)**	**2**									
Pleurobema coccinium **[SC] (Round Pigtoe)**	**2**	*****	**1**	**2**				**1**		**2**
Ptychobranchus fasciolaris **(Kidneyshell)**	**1**									
Quadrula pustulosa **(Pimpleback)**	**3**									
Strophitus undulatus **(Squawfoot)**	**4**	**1**	**7**			**2**		**2**	**3**	
Venustaconcha ellipsiformis **[SC] (Ellipse)**	**1**		**1**	**1**	**4**	**3**		*****	**44**	
Vilosa iris **[SC] (Rainbow)**	**1**	**2**	**10**	**6**	**10**	**6**	**1**	**2**	**7**	
Total # of Individuals		**54**	**101**	**55**	**88**	**59**	**32**	**121**	**101**	**20**
Total Native Species per site		**6**	**11**	**10**	**7**	**11**	**4**	**6**	**13**	**8**

Appendix II. *Cont.*

Mussel Species	TV	Sample Site								
		PR125	PR250	PR500	MR125	MR250	MR500	SH125	SH250	SH500
Actinonaias ligamentina **(Mucket)**	1	13								
Amblema plicata **(Three-ridge)**	3	4			9			29	6	3
Alasmidonta marginata [SC] **(Elktoe)**	2	5	1		1	1		17	5	
Alasmidonta viridis [SC] **(Slippershell)**	2		1	*		1			*	
Anodonta grandis **(Giant Floater)**	4	1		1	*	*	2	*	1	*
Anodonta imbecilis **(Paper pondshell)**	2							*	*	
Anodontoides ferussacianus **(Cylindrical papershell)**	2		*	1						
Cyclonaias tuberculata [SC] **(Purple Wartyback)**	2									
Elliptio dilatata **(Spike)**	2	*	141	42		24		*	*	
Epioblasma triquetra [T] **(Snuffbox)**	0				1					
Fusconaia flava **(Wabash Pigtoe)**	2	8	23	97	9	17		25	19	
Lampsilis fasciola [T] **(Wavy-rayed Lampmussel)**	2									
Lampsilis ventricosa **(Pocketbook)**	2	1	6	1	25	1		5	10	
Lampsilis siliquoidea **(Fatmucket)**	4	2	*	2	4	20	1	6	4	2
Lasmigona compressa **(Creek Heelsplitter)**	3			1					1	
Lasmigona complanata **(White Heelsplitter)**	4		*	*						
Lasmigona costata **(Fluted Shell)**	3	2	6	13	9	7		28	63	
Leptodea fragilis **(Pink Heelsplitter)**	3	*								
Ligumia recta **(Black Sandshell)**	2				8					
Pleurobema coccinium [SC] **(Round Pigtoe)**	2		9	101				7	9	
Ptychobranchus fasciolaris **(Kidneyshell)**	1		1	25	1			6	3	
Quadrula pustulosa **(Pimpleback)**	3				24					
Strophitus undulatus **(Squawfoot)**	4	5	6	13	*	2		8	3	
Venustaconcha ellipsiformis [SC] **(Ellipse)**	1				30				1	
Vilosa iris [SC] **(Rainbow)**	1	*	13	15		2		*	1	
Total # of Individuals		41	207	312	121	75	3	131	126	5
Total Native Species per site		9	10	12	11	9	2	9	13	2

Appendix III. Qualitative invertebrate species data from the combined Surber and multi-habitat dipnet sampling for sites with varied riparian forest buffer widths in the Grand (GR), Kalamazoo (KZ), Raisin (RR) and St. Joseph (SJ) rivers during 2000. Presence or absence is indicated by an "X." (L) indicates larvae in cases of the Coleoptera where adults were also collected and identified to species.

Family	Genus	GR125	GR250	GR500	KZ125	KZ250	KZ500	RR125	RR250	RR500	SJ125	SJ250	SJ500
Dytiscidae	***Hydroporus***		X										
	Ancyronyx variegata		X						X	X			X
	Dubiraphia sp. (L)	X		X			X	X		X	X	X	X
	Dubiraphia bivittata	X	X		X			X		X			
	Macronychus glabratus	X	X	X	X	X	X	X	X	X	X	X	X
	Optioservus fastiditus											X	
	Optioservus sp. (L)	X	X	X	X	X	X	X	X	X	X	X	X
Elmidae	***Optioservus ovalis***					X							
	Optioservus trivittatus	X			X		X						
	Stenelmis sp. (L)	X		X	X	X	X	X	X	X	X	X	X
	Stenelmis crenata	X			X			X	X	X	X	X	X
	Stenelmis decorata							X					
	Stenelmis grossa							X					
	Stenelmis musgravii				X	X							
Gyrinidae	***Dineutus sp. (L)***						X		X				
	Gyrinus sp.		X	X									
Hydrophilidae	***Sperchopsis sp.***	X			X	X	X		X				
Psephenidae	***Ectopria nervosa***	X			X		X		X				X
	Psephenus herricki				X	X	X		X			X	
Scirtidae	***Scirtes sp.***	X					X	X					
Athericidae	***Atherix variegata***	X			X		X			X			
Ceratopogonidae	***Bezzia/Palpomyia sp.***	X		X					X	X			X
	Probezzia sp.		X										
	Chironominae sp.	X		X	X	X	X	X	X	X	X	X	X
	Corynoneura sp.	X											
	Cricotopus sp.				X		X	X	X		X		X
	Microtendipes sp.				X	X						X	
	Orthocladiinae		X			X	X	X	X	X	X	X	X
	Orthocladiinae sp. 1	X	X	X	X	X	X	X	X	X	X	X	X
	Orthocladiinae sp. 2	X		X	X		X	X		X			X
Chironomidae	***Orthocladiinae sp. 3***												
	Paratendipes sp.	X		X	X		X		X			X	
	Polypedilum sp.	X		X	X				X	X		X	
	Stenochironomus sp.					X			X		X	X	
	Tanypodinae sp. 1	X	X	X	X	X	X	X	X	X	X	X	X
	Tanypodinae sp. 2	X	X	X	X	X	X	X	X	X	X	X	
	Tanypodinae sp. 3				X						X		
	Tanytarsini sp. 1	X	X	X	X			X	X	X			X

Appendix III. *Cont.*

Family	Genus	GR125	GR250	GR500	KZ125	KZ250	KZ500	RR125	RR250	RR500	SJ125	SJ250	SJ500
Chironomidae	***Xylotopus sp.***		X	X	X		X			X			
Empididae	***Chelifera sp.***										X	X	
	Clinocera sp.				X						X		
	Hemerodromia sp.	X		X	X		X	X	X	X	X	X	X
Pychodidae	***Psychoda sp.***	X											
Simuliidae	***Simulium sp.***	X	X	X		X	X		X	X	X	X	
Tabanidae	***Chrysops sp.***	X			X	X	X		X		X	X	
	Tabanus sp.										X		
Tipulidae	***Antocha sp.***	X			X	X	X		X			X	X
	Hexatoma sp.				X			X	X	X	X		
	Pedicia sp.								X		X		
	Tipula abdominalis						X						
Ameletidae	***Ameletus lineatus***						X		X		X		
Baetiscidae	***Baetisca laurentia***			X							X		X
Beatidae	***Acentrella sp.***	X											
	Acerpenna pygmaeus	X	X	X	X	X	X		X				
	Baetis sp.	X	X	X	X	X	X	X	X	X		X	X
	Baetis tricaudatus				X	X							
Caenidae	***Brachycercus sp.***								X				
	Caenis anceps				X		X		X		X	X	X
	Caenis hilaris				X	X	X		X		X		
Ephemerallidae	***Attenella attenuata***											X	
	Seratella deficiens									X			
	Timpanoga simplex						X						
Ephemeridae	***Ephemera simulans***				X						X		X
	Hexagenia limbata			X			X						
Heptageniidae	***Heptagenia flavescens***			X							X		
	Leucrocuta hebe								X	X			
	Stenacron interpunctatum	X	X	X				X			X	X	X
	Stenonema exiguum	X		X	X	X	X	X	X	X	X	X	X
	S. luteum						X					X	
	S. mediopunctatum				X		X		X		X	X	
	S. pulchellum	X		X		X		X	X		X	X	X
	S. terminatum	X	X	X	X	X	X	X	X	X	X	X	X
Isonychiidae	***Isonychia bicolor***	X			X	X	X		X	X		X	
Leptohyphidae	***Tricorythodes sp. 1***				X	X	X	X	X	X		X	
	Tricorythodes sp. 2					X		X					
Leptophlebiidae	***Paraleptophlebia sp.***								X		X		
Polymitarcyidae	***Epheron leukon***				X	X	X	X	X	X	X	X	X
Potamanthidae	***Anthopotamus distinctus***				X								
Belastomatidae	***Belastoma flumineum***		X										
Corixidae					X						X	X	X
Gerridae	***Gerris sp.***			X		X							
Veliidae	***Metrobates sp.***		X			X		X	X	X			
	Rhagovelia obesa						X	X	X	X	X		X
	Rheumatobates sp.			X				X	X	X			X

Appendix III. *Cont.*

Family	Genus	GR125	GR250	GR500	KZ125	KZ250	KZ500	RR125	RR250	RR500	SJ125	SJ250	SJ500
Pyralidae	***Parapoynx sp.***	X											
	Petrophila sp.				X	X							
Corydalidae	***Corydalus cornutus***								X				
	Nigronia serricornis	X					X					X	X
Sialidae	***Sialis sp.***				X		X		X		X		
Sysridae	***Climacia sp.***	X											
Aeschnidae	***Boyeria grafiana***	X					X						
	Boyeria vinosa	X			X	X	X	X	X	X	X		X
Calopterygidae	***Calopteryx maculata***	X	X	X		X	X	X	X		X	X	
	Haeterina titia	X							X	X	X		
Coenagrionidae	***Argia sp.***	X						X					
	Enallagma sp.										X		
Gomphidae	***Arigomphus furcifer***											X	
	Dromogomphus spinosus	X			X		X					X	
	Gomphus exilis	X					X						
	Gomphus lividus	X											
	Gomphus spiniceps				X								
	Hagenius brevistylus					X	X						
	Ophiogomphus asperius					X							
	Ophiogomphus carolinus						X	X				X	
	O. rupinsulensis				X		X	X		X		X	
	Stylogomphus albistylus				X		X					X	
	Stylurus amnicola			X	X								
	Stylurus notatus										X		
Chloroperlidae	***Utaperla gaspersium***							X	X		X		
Nemouridae	***Amphinemura sp.***								X				
Perlidae	***Acroneuria arida***	X							X	X	X		X
	Acroneuria ruralis								X				
	Paragnetina sp.	X					X				X	X	X
	Perlesta placida complex	X			X	X	X			X	X	X	X
Pteronarcyidae	***Pteronarcys sp.***				X	X	X				X	X	
	Pteronarcys biloba										X		
Brachycentridae	***Brachycentrus americanus***					X						X	
	Brachycentrus lateralis						X						
	Brachycentrus numerosus			X	X	X	X	X	X	X	X	X	X
	Micrasema sp.											X	
Glossosomatidae	***Glossosoma sp.***								X				X
Helicopsychidae	***Helicopsyche borealis***	X		X	X	X			X			X	X
Hydropsychidae	***Ceratopsyche alhedra***		X	X									
	Ceratopsyche bronta				X	X	X		X		X	X	X
	Ceratopsyche morosa				X		X		X		X	X	
	Ceratopsyche slossonae									X	X		
	Ceratopsyche sparna	X			X	X	X		X			X	X
	Ceratopsyche walkeri							X					
	Cheumatopsyche sp.	X	X	X	X		X	X	X	X	X	X	X
	Hydropsyche betteni		X		X				X				X
	Hydropsyche bidens									X			
	Hydropsyche demora					X							
	Hydropsyche hageni			X							X		
	Hydropsyche leonardi								X		X		

Appendix III. *Cont.*

Family	Genus	GR125	GR250	GR500	KZ125	KZ250	KZ500	RR125	RR250	RR500	SJ125	SJ250	SJ500
Hydropsychidae	*Hydropsyche orris*							X	X				
	Hydropsyche phalearata					X			X				
	Hydropsyche simulans	X	X	X	X	X		X	X	X		X	
	Macrostemum zebratum								X	X			
Hydroptilidae	*Hydroptila sp.*	X			X						X		
Lepidostomatidae	*Lepidostoma sp.*		X	X		X							
Leptoceridae	*Nectopsyche diarina*				X	X	X	X	X	X		X	X
	Nectopsyche exquisita							X			X	X	
	Mystacides sp.					X					X		
	Oecetis avara				X		X				X		
	Oecetis persimilis	X											
	Oecetis sp.							X					
	Trianoides ignitus	X						X	X				
	Trianoides marginatus	X	X										X
Limnephilidae	*Hydatophylax sp.*								X				
	Pycnopsyche sp.	X					X		X			X	
Molannidae	*Molanna flavicornis*										X		
Philopotamidae	*Chimarra sp.*	X					X		X	X		X	
Polycentropodidae	*Neureclipsis sp.*	X	X	X	X	X	X	X	X		X		
	Cyrnellus fraternus	X		X									
	Polycentropus sp.	X	X	X				X	X	X	X		X
Psychomidae	*Lype diversa*	X		X									
	Psychomyia flavida										X		
Rhyacophilidae	*Rhyacophila sp.*	X											
Uenoidae	*Neophylax sp.*	X			X	X			X		X	X	X
Acariformes			X		X			X	X	X	X	X	X
Hirundinia	*Glossisphonidae sp.*			X									
Oligochaeta	*Naididae sp.*	X	X	X									
	Tubificidae sp.	X	X	X	X	X	X	X	X	X	X	X	X
Cambaridae	*Orconectes propinquus*	X											X
	Orconectes rusticus	X	X	X	X		X	X		X	X	X	
Gammaridae	*Gammarus sp.*	X	X	X	X	X	X	X	X	X	X	X	X
	Hyallela azteca	X		X					X			X	
Isopoda	*Caecidotea sp.*	X	X	X		X		X			X		
Ancylidae	*Ferrissia sp.*	X		X		X	X	X	X	X	X		X
Hydrobiidae		X		X	X	X	X		X		X	X	X
Lymnaeidae	*Fossaria sp.*	X	X	X	X		X						X
Physidae	*Physa/Physella sp.*		X	X	X	X	X				X		X
Planorbiidae		X		X	X	X						X	X
Pleuroceridae		X		X									X
	Elimia sp.			X				X				X	
	Leptoxis sp.	X		X	X	X	X						X
Viviparidae	*Viviparus sp.*	X		X									
Corbiculidae	*Corbicula fluminea*				X	X				X			X
Sphaeridae	*Musculium sp.*	X		X				X	X	X	X	X	X
	Pisidium sp.	X	X	X	X		X	X	X	X	X	X	X
	Sphaerium sp.	X		X	X	X	X	X	X	X	X	X	X
Total species per site		**82**	**38**	**60**	**77**	**59**	**76**	**57**	**83**	**55**	**75**	**69**	**60**

Appendix IV. Qualitative invertebrate species data from the combined Surber and multi-habitat dipnet sampling for sites with varied riparian forest buffer widths in the Looking Glass (L), Maple (M), Pine (P), Red Cedar (R), Shiawassee (S) and Thornapple Rivers and Sycamore Creek (SC) watersheds during 2001. Presence or absence is indicated by an "X." (L) indicates larvae in cases of the Coleoptera where adults were also collected and identified to species.

		Sample Site														
Family	**Genus**	**L125**	**L250**	**M125**	**M250**	**M500**	**P125**	**P250**	**P500**	**R125**	**R250**	**S125**	**S500**	**S500**	**SC500**	**T250**
Dytiscidae	***Agabus***						X									
	Laccophilus proximus															X
Elmidae	***Ancyronyx variegata***										X					X
	***Dubiraphia* (L)**	X	X	X	X			X	X	X	X	X		X		X
	Dubiraphia bivittata		X	X	X	X		X	X	X			X	X		X
	Macronychus glabratus	X	X	X	X			X	X	X	X	X	X	X	X	X
	Optioservus fastiditus										X					
	***Optioservus* (L)**		X	X	X				X		X			X	X	
	Optioservus ovalis															X
	Optioservus trivittatus	X		X					X			X				
	***Stenelmis sp.* (L)**	X	X	X	X			X	X	X	X	X	X	X	X	X
	Stenelmis cheryli															
	Stenelmis crenata	X	X	X	X				X	X	X	X				
Gyrinidae	***Dineutus* (L)**	X				X	X					X	X	X		
Hydrophilidae	***Hydrobius sp.***				X										X	
	Sperchopsis sp.	X		X	X		X	X			X	X		X		
	Tropisternus	X		X			X					X				
Psephenidae	***Ectopria nervosa***							X								
	Psephenus herricki		X					X								
Scirtidae	***Scirtes sp.***			X			X				X					
Athericidae	***Atherix variegata***		X	X					X							
Ceratopogonidae	***Bezzia/Palpomyia sp.***								X				X			
Chironomidae	**sp 1**	X	X	X	X	X	X	X	X	X		X	X	X	X	X
	sp 2		X	X	X			X	X	X			X	X	X	X
	sp 3	X	X	X	X		X	X	X	X	X	X	X	X	X	X
	sp 4			X	X	X	X	X	X	X			X	X		X
	sp 5			X	X			X		X			X			
	sp 6	X	X	X	X							X	X			
	sp 7			X	X			X	X	X	X			X	X	
	sp 8	X	X	X		X	X				X	X		X	X	
	sp 9	X	X	X	X		X	X	X	X	X	X		X		
	sp 10	X										X				
	sp 11	X										X				
	sp 12				X	X	X	X	X	X	X					
	sp 13	X		X	X	X						X				

Appendix IV. *Cont.*

Family	Genus	Sample Site														
		L125	L250	M125	M250	M500	P125	P250	P500	R125	R250	S125	S500	S500	SC500	T250
Chironomidae	**sp 14**	X			X							X				
	sp 15	X	X	X			X		X			X				
	sp 16	X										X				
	sp 17	X	X	X	X		X	X	X		X	X		X	X	
	sp 18		X	X	X	X	X		X	X	X			X		
	sp 19			X	X	X	X	X	X						X	
	sp 20	X	X		X					X	X	X				
	sp 21	X			X		X				X	X				
	sp 22	X										X				
	sp 23		X							X	X					
Dixidae	***Dixa sp.***				X											
Empididae	***Chelifera sp.***		X	X	X				X	X				X		X
	Clinocera sp.															
	Hemerodromia sp.	X		X	X				X	X	X	X	X	X	X	X
Pychodidae	***Psychoda sp.***															
Simuliidae	***Simulium sp.***	X		X	X		X	X	X	X		X	X	X	X	
Tabanidae	***Chrysops sp.***	X			X		X	X	X		X	X		X		X
	Tabanus sp.															
Tipulidae	***Antocha sp.***		X	X	X			X	X	X	X				X	
	Dicranota sp.															
	Hexatoma sp.		X	X	X											
	Pedicia sp.	X										X				
Beatidae	***Acentrella sp.***	X	X	X	X		X					X			X	
	Acerpenna pygmaeus	X			X		X					X		X	X	
	Baetis sp.	X	X	X	X		X		X		X	X	X	X	X	
	Baetis tricaudatus		X		X			X		X				X		
	Procloeon sp.	X		X			X	X			X	X	X	X	X	X
Caenidae	***Brachycercus sp.***	X										X				
	Caenis anceps	X	X					X	X			X				
	Caenis hilaris	X	X	X			X				X	X				
	Caenis latipennis	X	X		X	X	X			X		X		X		
Ephemerallidae	***Attenella attenuata***															X
	Seratella deficiens							X								
Ephemeridae	***Ephemera simulans***		X		X					X			X			
	Hexagenia limbata					X										

Appendix IV. *Cont.*

Family	**Genus**	**Sample Site**														
		L125	**L250**	**M125**	**M250**	**M500**	**P125**	**P250**	**P500**	**R125**	**R250**	**S125**	**S500**	**S500**	**SC500**	**T250**
	Leucrocuta hebe		X					X			X					
	Stenacron interpunctatum	X	X		X	X	X	X			X	X				
	Stenonema exiguum	X		X				X	X		X	X		X		X
Heptageniidae	***Stenonema luteum***						X	X	X		X		X		X	X
	Stenonema mediopunctatum	X	X	X	X			X		X		X	X			
	Stenonema pulchellum			X	X			X	X				X	X	X	X
	Stenonema terminatum	X	X	X	X		X		X			X	X	X	X	
Isonychiidae	***Isonychia bicolor***		X	X				X	X		X					
	Tricorythodes sp1		X	X	X		X	X			X		X			
Leptohyphidae	***Tricorythodes sp2***			X	X											
Polymitarcyidae	***Epheron leukon***	X		X							X	X				
Potamanthidae	***Anthopotamus distinctus***			X			X									
Belastomatidae	***Belastoma flumineum***		X			X										
Corixidae	***Corisella sp.***			X		X	X				X			X		
Corixidae	***Corixa sp.***															
Gerridae	***Gerris sp.***		X	X	X	X									X	
	Metrobates sp.	X	X	X			X					X				
Veliidae	***Rhagovelia obesa***		X													
	Rheumatobates sp.	X		X								X				
Mesoveliidae	***Mesovelia sp.***				X											
Notanectidae	***Notanecta sp.***									X						
Pyralidae	***Parapoynx sp.***	X	X									X				
	Petrophila sp.						X									
Sialidae	***Sialis sp.***		X			X	X	X			X			X	X	
Aeschnidae	***Aeschna eremita***	X										X				
	Boyeria vinosa			X				X	X		X					
Calopterygidae	***Calopteryx maculata***	X	X	X	X		X	X	X		X	X			X	X
	Haeterina titia	X			X	X						X				X
Coenagrionidae	***Enallagma sp.***			X		X										
	Dromogomphus spinosus								X							
	Gomphus descriptus								X							
Gomphidae	***Gomphus exilis***		X						X							
	Gomphus lividus		X					X								
	Gomphus spiniceps		X								X				X	

Appendix IV. *Cont.*

		Sample Site														
Family	**Genus**	**L125**	**L250**	**M125**	**M250**	**M500**	**P125**	**P250**	**P500**	**R125**	**R250**	**S125**	**S500**	**S500**	**SC500**	**T250**
Gomphidae	***Hagenius brevistylus***							X			X					
	Ophiogomphus asperius							X	X		X					X
	Ophiogomphus rupinsulensis								X							
	Stylurus amnicola							X	X							
	Stylurus notatus										X			X	X	X
Leuctridae	***Leuctra sp.***		X													
Perlidae	***Acroneuria arida***										X					
	Neoperla sp.												X			
	Paragnetina sp.		X					X								
	Perlesta placida complex		X	X			X	X	X		X		X		X	X
Pteronarcyidae	***Pteronarcys sp.***		X													
Brachycentridae	***Brachycentrus lateralis***				X								X	X		
	Brachycentrus numerosus	X			X			X	X	X		X	X	X	X	X
	Micrasema sp.													X		X
Glossosomatidae	***Glossosoma sp.***	X		X								X				
Helicopsychidae	***Helicopsyche borealis***	X	X		X		X	X	X	X		X	X	X		X
Hydropsychidae	***Ceratopsyche alhedra***													X		
	Ceratopsyche bronta	X	X	X	X		X	X	X			X		X		X
	Ceratopsyche morosa	X			X		X	X		X		X	X	X		X
	Ceratopsyche sparna	X	X					X	X	X	X	X			X	
	Ceratopsyche walkeri		X		X				X				X			
	Cheumatopsyche sp.	X	X	X	X		X	X	X	X	X	X	X	X	X	X
	Hydropsyche betteni	X	X	X	X				X	X		X	X	X		X
	Hydropsyche bidens			X												
	Hydropsyche cuanis	X					X				X	X				
	Hydropsyche leonardi	X										X				
	Hydropsyche phalearata	X					X					X	X			
	Hydropsyche simulans	X										X	X	X	X	
	Macrostemum zebratum	X										X				
Hydroptilidae	***Hydroptila sp.***	X	X	X					X	X		X	X			
Lepidostomatidae	***Lepidostoma sp.***		X													

Appendix IV. *Cont.*

Family	Genus	Sample Site														
		L125	L250	M125	M250	M500	P125	P250	P500	R125	R250	S125	S500	S500	SC500	T250
Leptoceridae	*Nectopsyche diarina*	X		X	X	X	X	X				X	X	X		
	Nectopsyche exquisita	X		X		X	X		X		X	X				
	Mystacides sp.		X													
	Oecetis avara	X										X				
	Oecetis persimilis	X			X							X				
	Oecetis sp.		X	X							X					
	Trianoides marginatus	X									X	X				
Limnephilidae	*Hydatophylax sp.*												X	X	X	X
	Pycnopsyche sp.				X			X	X		X			X		X
Philopotamidae	*Chimarra sp.*		X	X	X					X				X	X	X
Polycentropodidae	*Neureclipsis sp.*	X	X	X			X				X	X		X		
	Cyrnellus fraternus	X										X				
	Polycentropus sp.	X							X			X				
Psychomidae	*Psychomyia flavida*	X	X		X						X	X				
Uenoidae	*Neophylax sp.*	X	X	X	X			X	X			X	X	X		X
Glossisphonidae		X	X	X	X		X	X	X		X	X		X	X	X
					X		X			X			X			
		X										X				
Naididae								X								
Tubificidae		X		X	X	X	X	X			X	X			X	
Cambaridae	*Orconectes propinquus*	X	X		X			X	X			X				
	Orconectes rusticus		X	X		X	X	X		X	X		X	X	X	X
Gammaridae	*Gammarus sp*		X	X				X	X	X	X		X	X	X	X
	Hyallela azteca	X		X	X	X	X					X				
Isopoda	*Caecidotea sp.*		X	X	X					X	X		X	X	X	X
Ancylidae	*Ferrissia sp.*	X	X	X	X			X	X	X		X	X	X		X
Hydrobiidae		X	X	X	X			X	X	X	X	X	X	X	X	X
Lymnaeidae	*Fossaria sp.*		X		X			X		X			X		X	
Physidae	*Physa/Physella sp.*	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Planorbiidae				X		X		X						X		
Pleuroceridae		X	X	X							X	X				
	Elimia sp.	X	X		X			X	X		X	X				
	Leptoxis sp.		X	X	X			X	X	X	X		X	X		X
Valvatidae	*Valvata sp.*		X		X			X	X	X			X	X		X

Appendix IV. *Cont.*

Family	Genus	Sample Site														
		L125	**L250**	**M125**	**M250**	**M500**	**P125**	**P250**	**P500**	**R125**	**R250**	**S125**	**S500**	**S500**	**SC500**	**T250**
Viviparidae	***Viviparus sp.***									**X**						
Corbiculidae	***Corbicula fluminea***									**X**			**X**		**X**	
Sphaeridae	***Pisidium sp.***	**X**										**X**				**X**
	Sphaerium sp.	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Total #Species/Site		**82**	**77**	**76**	**75**	**24**	**51**	**65**	**63**	**46**	**62**	**82**	**48**	**58**	**43**	**46**

Appendix V. Native plant species observed during the riparian ecosystem study. Coefficients of conservatism (C), wetness classes and physiognomy descriptions are provided for each species.

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Acalypha rhomboidea	THREE SEEDED MERCURY	0	FACU	Nt A-Forb
Acer negundo	BOX ELDER	0	FACW-	Nt Tree
Acer nigrum	BLACK MAPLE	4	FACU	Nt Tree
Acer rubrum	RED MAPLE	1	FAC	Nt Tree
Acer saccharinum	SILVER MAPLE	2	FACW	Nt Tree
Acer saccharum	SUGAR MAPLE	5	FACU	Nt Tree
Achillea millefolium	YARROW	1	FACU	Nt P-Forb
Acorus calamus	SWEET FLAG	6	OBL	Nt P-Forb
Actaea pachypoda	DOLL'S EYES	7	UPL	Nt P-Forb
Actaea rubra	RED BANEBERRY	7	UPL	Nt P-Forb
Adiantum pedatum	MAIDENHAIR FERN	6	FAC-	Nt Fern
Aesculus glabra	OHIO BUCKEYE	6	FAC+	Nt Tree
Agalinis purpurea	PURPLE GERARDIA	7	FACW	Nt A-Forb
Agrimonia gryposepala	TALL AGRIMONY	2	FACU+	Nt P-Forb
Agrimonia pubescens	SOFT AGRIMONY	5	UPL	Nt P-Forb
Alisma plantago-aquatica	WATER PLANTAIN	1	OBL	Nt P-Forb
Allium cernuum	NODDING WILD ONION	5	UPL	Nt P-Forb
Allium tricoccum	WILD LEEK	5	FACU+	Nt P-Forb
Alnus rugosa	TAG ALDER	5	OBL	Nt Shrub
Amaranthus tuberculatus	WATER HEMP	6	OBL	Nt A-Forb
Ambrosia artemisiifolia	COMMON RAGWEED	0	FACU	Nt A-Forb
Ambrosia trifida	GIANT RAGWEED	0	FAC+	Nt A-Forb
Amelanchier arborea	JUNEBERRY	4	FACU	Nt Tree
Amphicarpaea bracteata	HOG PEANUT	5	FAC	Nt A-Forb
Anemone canadensis	CANADA ANEMONE	4	FACW	Nt P-Forb
Anemone quinquefolia	WOOD ANEMONE	5	FAC	Nt P-Forb
Anemone virginiana	THIMBLEWEED	3	UPL	Nt P-Forb
Anemonella thalictroides	RUE ANEMONE	8	UPL	Nt P-Forb
Angelica atropurpurea	ANGELICA	6	OBL	Nt P-Forb
Antennaria parlinii	SMOOTH PUSSYTOES	2	UPL	Nt P-Forb
Apios americana	GROUNDNUT	3	FACW	Nt P-Forb
Apocynum androsaemifolium	SPREADING DOGBANE	3	UPL	Nt P-Forb
Apocynum cannabinum	INDIAN HEMP	3	FAC	Nt P-Forb
Arabis laevigata	SMOOTH BANK CRESS	5	UPL	Nt B-Forb
Arenaria lateriflora	WOOD SANDWORT	5	FACU	Nt P-Forb
Arisaema dracontium	GREEN DRAGON	8	FACW	Nt P-Forb
Arisaema triphyllum	JACK IN THE PULPIT	5	FACW-	Nt P-Forb
Aristida basiramea	FORK TIPPED THREE AWNED GRASS	3	UPL	Nt A-Grass
Aristida necopina	THREE AWNED GRASS	4	UPL	Nt A-Grass
Asarum canadense	WILD GINGER	5	UPL	Nt P-Forb
Asclepias incarnata	SWAMP MILKWEED	6	OBL	Nt P-Forb
Asclepias syriaca	COMMON MILKWEED	1	UPL	Nt P-Forb
Asimina triloba	PAWPAW	9	FAC	Nt Tree
Asplenium platyneuron	EBONY SPLEENWORT	2	FACU	Nt Fern
Aster cordifolius	HEART LEAVED ASTER	4	UPL	Nt P-Forb
Aster lateriflorus	SIDE FLOWERING ASTER	2	FACW-	Nt P-Forb
Aster macrophyllus	BIG LEAVED ASTER	4	UPL	Nt P-Forb
Aster novae-angliae	NEW ENGLAND ASTER	3	FACW	Nt P-Forb
Aster oolentangiensis	PRAIRIE HEART LEAVED ASTER	4	UPL	Nt P-Forb
Aster pilosus	HAIRY ASTER	1	FACU+	Nt P-Forb
Aster puniceus	SWAMP ASTER	5	OBL	Nt P-Forb

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Aster umbellatus	TALL FLAT TOP WHITE ASTER	5	FACW	Nt P-Forb
Athyrium filix-femina	LADY FERN	4	FAC	Nt Fern
Athyrium thelypterioides	SILVERY SPLEENWORT	6	FAC	Nt Fern
Betula papyrifera	PAPER BIRCH	2	FACU+	Nt Tree
Bidens cernuus	NODDING BUR MARIGOLD	3	OBL	Nt A-Forb
Bidens frondosus	COMMON BEGGAR TICKS	1	FACW	Nt A-Forb
Bidens vulgatus	TALL BEGGAR TICKS	0	FACW	Nt A-Forb
Boehmeria cylindrica	FALSE NETTLE	5	OBL	Nt P-Forb
Botrychium dissectum	CUT LEAVED GRAPE FERN	5	FAC	Nt Fern
Botrychium virginianum	RATTLESNAKE FERN	5	FACU	Nt Fern
Brachyelytrum erectum	LONG AWNED WOOD GRASS	7	UPL	Nt P-Grass
Bromus latiglumis	EAR LEAVED BROME	6	FACW-	Nt P-Grass
Bromus pubescens	CANADA BROME	5	FACU	Nt P-Grass
Cacalia atriplicifolia	PALE INDIAN PLANTAIN	10	UPL	Nt P-Forb
Calamagrostis canadensis	BLUE JOINT GRASS	3	OBL	Nt P-Grass
Callitriche verna	WATER STARWORT	6	OBL	Nt P-Forb
Caltha palustris	MARSH MARIGOLD	6	OBL	Nt P-Forb
Calystegia sepium	HEDGE BINDWEED	2	FAC	Nt P-Forb
Campanula americana	TALL BELLFLOWER	8	FAC	Nt A-Forb
Campanula aparinoides	MARSH BELLFLOWER	7	OBL	Nt P-Forb
Campanula rotundifolia	HAREBELL	6	FAC-	Nt P-Forb
Cardamine bulbosa	SPRING CRESS	4	OBL	Nt P-Forb
Cardamine pratensis	CUCKOO FLOWER	10	OBL	Nt P-Forb
Carex albursina	SEDGE	5	UPL	Nt P-Sedge
Carex alopecoidea	SEDGE	3	FACW+	Nt P-Sedge
Carex amphibola	SEDGE	8	FACW-	Nt P-Sedge
Carex aquatilis	SEDGE	7	OBL	Nt P-Sedge
Carex arctata	SEDGE	3	UPL	Nt P-Sedge
Carex bebbii	SEDGE	4	OBL	Nt P-Sedge
Carex bicknellii	SEDGE	10	FAC-	Nt P-Sedge
Carex blanda	SEDGE	1	FAC	Nt P-Sedge
Carex brevior	SEDGE	3	FAC	Nt P-Sedge
Carex bromoides	SEDGE	6	FACW+	Nt P-Sedge
Carex cephaloidea	SEDGE	5	FACU+	Nt P-Sedge
Carex cephalophora	SEDGE	3	FACU	Nt P-Sedge
Carex crinita	SEDGE	4	FACW+	Nt P-Sedge
Carex davisii	DAVIS' SEDGE	8	FAC+	Nt P-Sedge
Carex deweyana	SEDGE	3	FACU-	Nt P-Sedge
Carex digitalis	SEDGE	5	UPL	Nt P-Sedge
Carex formosa	SEDGE	10	FACW-	Nt P-Sedge
Carex frankii	FRANK'S SEDGE	4	OBL	Nt P-Sedge
Carex gracilescens	SEDGE	5	UPL	Nt P-Sedge
Carex gracillima	SEDGE	4	FACU	Nt P-Sedge
Carex granularis	SEDGE	2	FACW+	Nt P-Sedge
Carex grayi	SEDGE	6	FACW+	Nt P-Sedge
Carex hirtifolia	SEDGE	5	UPL	Nt P-Sedge
Carex hitchcockiana	SEDGE	5	UPL	Nt P-Sedge
Carex hystericina	SEDGE	2	OBL	Nt P-Sedge
Carex intumescens	SEDGE	3	FACW+	Nt P-Sedge
Carex jamesii	JAMES' SEDGE	8	UPL	Nt P-Sedge
Carex lacustris	SEDGE	6	OBL	Nt P-Sedge

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Carex laevivaginata	SEDGE	8	OBL	Nt P-Sedge
Carex laxiculmis	SEDGE	8	UPL	Nt P-Sedge
Carex laxiflora	SEDGE	8	FAC	Nt P-Sedge
Carex leptalea	SEDGE	5	OBL	Nt P-Sedge
Carex leptonervia	SEDGE	3	FAC	Nt P-Sedge
Carex lupulina	SEDGE	4	OBL	Nt P-Sedge
Carex lurida	SEDGE	3	OBL	Nt P-Sedge
Carex molesta	SEDGE	2	FACU+	Nt P-Sedge
Carex muskingumensis	SEDGE	6	OBL	Nt P-Sedge
Carex normalis	SEDGE	5	FACW	Nt P-Sedge
Carex pensylvanica	SEDGE	4	UPL	Nt P-Sedge
Carex plantaginea	SEDGE	8	UPL	Nt P-Sedge
Carex prairea	SEDGE	10	FACW+	Nt P-Sedge
Carex projecta	SEDGE	3	FACW+	Nt P-Sedge
Carex retrorsa	SEDGE	3	OBL	Nt P-Sedge
Carex rosea	CURLY STYLED WOOD SEDGE	2	UPL	Nt P-Sedge
Carex rostrata	SEDGE	10	OBL	Nt P-Sedge
Carex sparganioides	SEDGE	5	FAC	Nt P-Sedge
Carex sprengelii	SEDGE	5	FAC	Nt P-Sedge
Carex squarrosa	SEDGE	9	OBL	Nt P-Sedge
Carex stipata	SEDGE	1	OBL	Nt P-Sedge
Carex stricta	SEDGE	4	OBL	Nt P-Sedge
Carex swanii	SEDGE	4	FACU	Nt P-Sedge
Carex tenera	SEDGE	4	FAC+	Nt P-Sedge
Carex trichocarpa	HAIRY FRUITED SEDGE	8	OBL	Nt P-Sedge
Carex tuckermanii	SEDGE	8	OBL	Nt P-Sedge
Carex vesicaria	SEDGE	7	OBL	Nt P-Sedge
Carex vulpinoidea	SEDGE	1	OBL	Nt P-Sedge
Carex woodii	SEDGE	8	FAC	Nt P-Sedge
Carpinus caroliniana	BLUE BEECH	6	FAC	Nt Tree
Carya cordiformis	BITTERNUT HICKORY	5	FAC	Nt Tree
Carya glabra	PIGNUT HICKORY	5	FACU	Nt Tree
Carya laciniosa	SHELLBARK HICKORY	9	FACW	Nt Tree
Carya ovata	SHAGBARK HICKORY	5	FACU	Nt Tree
Caulophyllum thalictroides	BLUE COHOSH	5	UPL	Nt P-Forb
Celastrus scandens	AMERICAN BITTERSWEET	3	FACU	Nt W-Vine
Celtis occidentalis	HACKBERRY	5	FAC-	Nt Tree
Cephalanthus occidentalis	BUTTONBUSH	7	OBL	Nt Shrub
Cerastium arvense	FIELD CHICKWEED	6	FACU-	Nt P-Forb
Cercis canadensis	REDBUD	8	FACU	Nt Tree
Chelone glabra	TURTLEHEAD	7	OBL	Nt P-Forb
Chrysosplenium americanum	GOLDEN SAXIFRAGE	6	OBL	Nt P-Forb
Cicuta maculata	WATER HEMLOCK	4	OBL	Nt B-Forb
Cinna arundinacea	WOOD REEDGRASS	7	FACW	Nt P-Grass
Circaea lutetiana	ENCHANTER'S NIGHTSHADE	2	FACU	Nt P-Forb
Cirsium discolor	PASTURE THISTLE	4	UPL	Nt B-Forb
Cirsium muticum	SWAMP THISTLE	6	OBL	Nt B-Forb
Claytonia virginica	SPRING BEAUTY	4	FACU	Nt P-Forb
Clematis virginiana	VIRGIN'S BOWER	4	FAC	Nt W-Vine
Collinsonia canadensis	RICHWEED	8	FAC	Nt P-Forb
Conopholis americana	SQUAWROOT	10	UPL	Nt P-Forb

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Conyza canadensis	HORSEWEED	0	FAC-	Nt A-Forb
Cornus alternifolia	ALTERNATE LEAVED DOGWOOD	5	UPL	Nt Tree
Cornus amomum	SILKY DOGWOOD	2	FACW+	Nt Shrub
Cornus florida	FLOWERING DOGWOOD	8	FACU-	Nt Tree
Cornus foemina	GRAY DOGWOOD	1	FACW-	Nt Shrub
Cornus stolonifera	RED OSIER DOGWOOD	2	FACW	Nt Shrub
Corylus americana	HAZELNUT	5	FACU-	Nt Shrub
Crataegus chrysocarpa	HAWTHORN	4	UPL	Nt Tree
Crataegus crus-galli	COCKSPUR THORN	5	FAC	Nt Tree
Crataegus mollis	HAWTHORN	2	FACW-	Nt Tree
Cryptotaenia canadensis	HONEWORT	2	FAC	Nt P-Forb
Cuscuta gronovii	COMMON DODDER	3	FACW	Nt A-Forb
Cyperus esculentus	FIELD NUT SEDGE	1	FACW	Nt P-Sedge
Cyperus filiculmis	SLENDER SAND SEDGE	2	FACU-	Nt P-Sedge
Cyperus strigosus	LONG SCALED NUT SEDGE	3	FACW	Nt P-Sedge
Cystopteris bulbifera	BULBLET FERN	5	FACW-	Nt Fern
Cystopteris fragilis	FRAGILE FERN	4	FACU	Nt Fern
Decodon verticillatus	WHORLED or SWAMP LOOSESTRIFE	7	OBL	Nt Shrub
Dentaria laciniata	CUT LEAVED TOOTHWORT	5	FACU	Nt P-Forb
Desmodium canadense	SHOWY TICK TREFOIL	3	FAC-	Nt P-Forb
Desmodium glutinosum	CLUSTERED LEAVED TICK TREFOIL	5	UPL	Nt P-Forb
Diarrhena obovata	BEAK GRASS	9	FACW	Nt P-Grass
Dioscorea villosa	WILD YAM	4	FAC-	Nt P-Forb
Diphasiastrum digitatum	GROUND CEDAR	3	UPL	Nt Fern Ally
Dryopteris carthusiana	SPINULOSE WOODFERN	5	FACW-	Nt Fern
Dryopteris cristata	CRESTED SHIELD FERN	6	OBL	Nt Fern
Dryopteris goldiana	GOLDIE'S WOODFERN	10	FAC	Nt Fern
Dryopteris intermedia	EVERGREEN WOODFERN	5	FAC	Nt Fern
Echinochloa muricata	BARNYARD GRASS	1	OBL	Nt A-Grass
Echinocystis lobata	WILD CUCUMBER	2	FACW-	Nt A-Forb
Elodea canadensis	COMMON WATERWEED	1	OBL	Nt P-Forb
Elymus canadensis	CANADA WILD RYE	7	FAC-	Nt P-Grass
Elymus villosus	SILKY WILD RYE	5	FACU	Nt P-Grass
Elymus virginicus	VIRGINIA WILD RYE	4	FACW-	Nt P-Grass
Epifagus virginiana	BEECH DROPS	10	UPL	Nt P-Forb
Epilobium coloratum	CINNAMON WILLOW HERB	3	OBL	Nt P-Forb
Equisetum arvense	COMMON HORSETAIL	0	FAC	Nt Fern Ally
Equisetum fluviatile	WATER HORSETAIL	7	OBL	Nt Fern Ally
Equisetum hyemale	SCOURING RUSH	2	FACW-	Nt Fern Ally
Equisetum laevigatum	SMOOTH SCOURING RUSH	2	FACW	Nt Fern Ally
Eragrostis hypnoides	CREEPING LOVE GRASS	8	OBL	Nt A-Grass
Erigeron annuus	ANNUAL FLEABANE	0	FAC-	Nt B-Forb
Erigeron philadelphicus	MARSH FLEABANE	2	FACW	Nt P-Forb
Euonymus atropurpurea	WAHOO; BURNING BUSH	8	FAC-	Nt Shrub
Euonymus obovata	RUNNING STRAWBERRY BUSH	5	UPL	Nt Shrub
Eupatorium maculatum	JOE PYE WEED	4	OBL	Nt P-Forb
Eupatorium perfoliatum	COMMON BONESET	4	FACW+	Nt P-Forb
Eupatorium purpureum	PURPLE JOE PYE WEED	5	FAC	Nt P-Forb
Eupatorium rugosum	WHITE SNAKEROOT	4	FACU	Nt P-Forb
Euphorbia corollata	FLOWERING SPURGE	4	UPL	Nt P-Forb
Euthamia graminifolia	GRASS LEAVED GOLDENROD	3	FACW-	Nt P-Forb

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Fagus grandifolia	AMERICAN BEECH	6	FACU	Nt Tree
Festuca subverticillata	NODDING FESCUE	5	FACU+	Nt P-Grass
Fragaria vesca	WOODLAND STRAWBERRY	2	FACU-	Nt P-Forb
Fragaria virginiana	WILD STRAWBERRY	2	FAC-	Nt P-Forb
Fraxinus americana	WHITE ASH	5	FACU	Nt Tree
Fraxinus nigra	BLACK ASH	6	FACW+	Nt Tree
Fraxinus pennsylvanica	RED ASH	2	FACW	Nt Tree
Fraxinus profunda	PUMPKIN ASH	9	OBL	Nt Tree
Galium aparine	ANNUAL BEDSTRAW	0	FACU	Nt A-Forb
Galium boreale	NORTHERN BEDSTRAW	3	FAC	Nt P-Forb
Galium circaezans	WHITE WILD LICORICE	4	FACU-	Nt P-Forb
Galium labradoricum	BOG BEDSTRAW	8	OBL	Nt P-Forb
Galium lanceolatum	YELLOW WILD LICORICE	4	UPL	Nt P-Forb
Galium obtusum	WILD MADDER	5	OBL	Nt P-Forb
Galium tinctorium	STIFF BEDSTRAW	5	OBL	Nt P-Forb
Galium triflorum	FRAGRANT BEDSTRAW	4	FACU+	Nt P-Forb
Geranium maculatum	WILD GERANIUM	4	FACU	Nt P-Forb
Geum canadense	WHITE AVENS	1	FAC	Nt P-Forb
Geum laciniatum	ROUGH AVENS	2	FACW	Nt P-Forb
Geum rivale	PURPLE AVENS	7	OBL	Nt P-Forb
Gleditsia triacanthos	HONEY LOCUST	8	FAC	Nt Tree
Glyceria canadensis	RATTLESNAKE GRASS	8	OBL	Nt P-Grass
Glyceria striata	FOWL MANNA GRASS	4	OBL	Nt P-Grass
Gnaphalium obtusifolium	OLD FIELD BALSAM	2	UPL	Nt A-Forb
Gymnocladus dioicus	KENTUCKY COFFEE TREE	9	UPL	Nt Tree
Hackelia virginiana	BEGGAR'S LICE	1	FAC-	Nt P-Forb
Hamamelis virginiana	WITCH HAZEL	5	FACU	Nt Shrub
Helenium autumnale	SNEEZEWEED	5	FACW+	Nt P-Forb
Helianthemum bicknellii	ROCKROSE	10	UPL	Nt P-Forb
Helianthus giganteus	TALL SUNFLOWER	5	FACW	Nt P-Forb
Helianthus strumosus	PALE LEAVED SUNFLOWER	4	UPL	Nt P-Forb
Hepatica acutiloba	SHARP LOBED HEPATICA	8	UPL	Nt P-Forb
Hepatica americana	ROUND LOBED HEPATICA	6	UPL	Nt P-Forb
Hieracium longipilum	LONG BEARDED HAWKWEED	6	UPL	Nt P-Forb
Hydrocotyle americana	WATER PENNYWORT	6	OBL	Nt P-Forb
Hydrophyllum virginianum	VIRGINIA WATERLEAF	4	FACW-	Nt P-Forb
Hypericum ascyron	GIANT ST. JOHN'S WORT	8	FAC+	Nt P-Forb
Hypericum prolificum	SHRUBBY ST.JOHN'S WORT	5	FACU	Nt Shrub
Hypericum punctatum	SPOTTED ST. JOHN'S WORT	4	FAC+	Nt P-Forb
Hystrix patula	BOTTLEBRUSH GRASS	5	UPL	Nt P-Grass
Ilex verticillata	MICHIGAN HOLLY	5	FACW+	Nt Shrub
Impatiens capensis	SPOTTED TOUCH ME NOT	2	FACW	Nt A-Forb
Impatiens pallida	PALE TOUCH ME NOT	6	FACW	Nt A-Forb
Iris virginica	SOUTHERN BLUE FLAG	5	OBL	Nt P-Forb
Juglans cinerea	BUTTERNUT	5	FACU+	Nt Tree
Juglans nigra	BLACK WALNUT	5	FACU	Nt Tree
Juncus biflorus	TWO FLOWERED RUSH	8	FACW	Nt P-Forb
Juncus brachycephalus	RUSH	7	OBL	Nt P-Forb
Juncus effusus	SOFT STEMMED RUSH	3	OBL	Nt P-Forb
Juncus tenuis	PATH RUSH	1	FAC	Nt P-Forb
Juniperus virginiana	RED CEDAR	3	FACU	Nt Tree

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Lactuca biennis	TALL BLUE LETTUCE	2	FAC	Nt B-Forb
Laportea canadensis	WOOD NETTLE	4	FACW	Nt P-Forb
Larix laricina	TAMARACK	5	FACW	Nt Tree
Lathyrus palustris	MARSH PEA	7	FACW	Nt P-Forb
Leersia oryzoides	CUT GRASS	3	OBL	Nt P-Grass
Leersia virginica	WHITE GRASS	5	FACW	Nt P-Grass
Lemna minor	SMALL DUCKWEED	5	OBL	Nt A-Forb
Leptoloma cognatum	FALL WITCH GRASS	3	UPL	Nt P-Grass
Lilium michiganense	MICHIGAN LILY	5	FAC+	Nt P-Forb
Lindera benzoin	SPICEBUSH	7	FACW-	Nt Shrub
Liriodendron tulipifera	TULIP TREE	9	FACU+	Nt Tree
Lithospermum latifolium	BROAD LEAVED PUCCOON	10	UPL	Nt P-Forb
Lobelia cardinalis	CARDINAL FLOWER	7	OBL	Nt P-Forb
Lobelia siphilitica	GREAT BLUE LOBELIA	4	FACW+	Nt P-Forb
Lonicera dioica	RED HONEYSUCKLE	5	FACU	Nt W-Vine
Ludwigia palustris	WATER PURSLANE	4	OBL	Nt P-Forb
Luzula acuminata	HAIRY WOOD RUSH	5	FAC-	Nt P-Forb
Luzula multiflora	COMMON WOOD RUSH	5	FACU	Nt P-Forb
Lycopus americanus	COMMON WATER HOREHOUND	2	OBL	Nt P-Forb
Lycopus uniflorus	NORTHERN BUGLE WEED	2	OBL	Nt P-Forb
Lysimachia ciliata	FRINGED LOOSESTRIFE	4	FACW	Nt P-Forb
Lysimachia quadriflora	WHORLED LOOSESTRIFE	10	OBL	Nt P-Forb
Lysimachia terrestris	SWAMP CANDLES	6	OBL	Nt P-Forb
Lysimachia thyrsiflora	TUFTED LOOSESTRIFE	6	OBL	Nt P-Forb
Maianthemum canadense	CANADA MAYFLOWER	4	FAC	Nt P-Forb
Malus coronaria	AMERICAN CRAB	4	UPL	Nt Tree
Matteuccia struthiopteris	OSTRICH FERN	3	FACW	Nt Fern
Menispermum canadense	MOONSEED	5	FAC	Nt W-Vine
Mentha arvensis	WILD MINT	3	FACW	Nt P-Forb
Mimulus ringens	MONKEY FLOWER	5	OBL	Nt P-Forb
Mitella diphylla	BISHOP'S CAP	8	FACU+	Nt P-Forb
Morus rubra	RED MULBERRY	9	FAC-	Nt Tree
Muhlenbergia frondosa	COMMON SATIN GRASS	3	FACW	Nt P-Grass
Muhlenbergia mexicana	LEAFY SATIN GRASS	3	FACW	Nt P-Grass
Muhlenbergia schreberi	NIMBLEWILL	0	FAC	Nt P-Grass
Muhlenbergia sylvatica	WOODLAND SATIN GRASS	8	FACW	Nt P-Grass
Nuphar advena	YELLOW POND LILY	8	OBL	Nt P-Forb
Nuphar variegata	YELLOW POND LILY	7	OBL	Nt P-Forb
Nyssa sylvatica	BLACK GUM	9	FACW+	Nt Tree
Onoclea sensibilis	SENSITIVE FERN	2	FACW	Nt Fern
Osmorhiza claytonii	HAIRY SWEET CICELY	4	FACU-	Nt P-Forb
Osmorhiza longistylis	SMOOTH SWEET CICELY	3	FACU-	Nt P-Forb
Osmunda cinnamomea	CINNAMON FERN	5	FACW	Nt Fern
Osmunda regalis	ROYAL FERN	5	OBL	Nt Fern
Ostrya virginiana	IRONWOOD; HOP HORNBEAM	5	FACU-	Nt Tree
Oxalis stricta	COMMON YELLOW WOOD SORREL	0	FACU	Nt P-Forb
Panicum capillare	WITCH GRASS	1	FAC	Nt A-Grass
Panicum clandestinum	PANIC GRASS	3	FACW	Nt P-Grass
Panicum columbianum	PANIC GRASS	7	UPL	Nt P-Grass
Panicum implicatum	PANIC GRASS	3	FAC	Nt P-Grass
Panicum praecocius	PANIC GRASS	8	UPL	Nt P-Grass

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Parthenocissus quinquefolia	VIRGINIA CREEPER	5	FAC-	Nt W-Vine
Pedicularis lanceolata	SWAMP BETONY	8	FACW+	Nt P-Forb
Peltandra virginica	ARROW ARUM	6	OBL	Nt P-Forb
Penstemon digitalis	FOXGLOVE BEARD TONGUE	2	FAC-	Nt P-Forb
Penstemon hirsutus	HAIRY BEARD TONGUE	5	UPL	Nt P-Forb
Penthorum sedoides	DITCH STONECROP	3	OBL	Nt P-Forb
Phalaris arundinacea	REED CANARY GRASS	0	FACW+	Nt P-Grass
Phlox divaricata	WOODLAND PHLOX	5	FACU	Nt P-Forb
Phragmites australis	REED	0	FACW+	Nt P-Grass
Phryma leptostachya	LOPSEED	4	UPL	Nt P-Forb
Physalis longifolia	LONG LEAVED GROUND CHERRY	1	UPL	Nt P-Forb
Physocarpus opulifolius	NINEBARK	4	FACW-	Nt Shrub
Phytolacca americana	POKEWEED	2	FAC-	Nt P-Forb
Pilea fontana	BOG CLEARWEED	5	FACW	Nt A-Forb
Pilea pumila	CLEARWEED	5	FACW	Nt A-Forb
Pinus resinosa	RED PINE	6	FACU	Nt Tree
Pinus strobus	WHITE PINE	3	FACU	Nt Tree
Platanus occidentalis	SYCAMORE	7	FACW	Nt Tree
Poa alsodes	BLUEGRASS	9	FACW-	Nt P-Grass
Poa nemoralis	BLUEGRASS	5	FAC	Nt P-Grass
Poa sylvestris	WOODLAND BLUEGRASS	8	FAC	Nt P-Grass
Podophyllum peltatum	MAY APPLE	3	FACU	Nt P-Forb
Polygonatum biflorum	SOLOMON SEAL	4	FACU	Nt P-Forb
Polygonatum pubescens	DOWNY SOLOMON SEAL	5	UPL	Nt P-Forb
Polygonum amphibium	WATER SMARTWEED	6	OBL	Nt P-Forb
Polygonum hydropiper	WATER PEPPER	1	OBL	Nt A-Forb
Polygonum hydropiperoides	WATER PEPPER	5	OBL	Nt P-Forb
Polygonum lapathifolium	NODDING SMARTWEED	0	FACW+	Nt A-Forb
Polygonum pensylvanicum	BIGSEED SMARTWEED	0	FACW+	Nt A-Forb
Polygonum punctatum	SMARTWEED	5	OBL	Nt A-Forb
Polygonum sagittatum	ARROW LEAVED TEAR THUMB	5	OBL	Nt A-Forb
Polygonum virginianum	JUMPSEED	4	FAC	Nt P-Forb
Polymnia canadensis	LEAFCUP	6	UPL	Nt P-Forb
Polystichum acrostichoides	CHRISTMAS FERN	6	UPL	Nt Fern
Pontederia cordata	PICKEREL WEED	8	OBL	Nt P-Forb
Populus deltoides	COTTONWOOD	1	FAC+	Nt Tree
Populus grandidentata	BIG TOOTHED ASPEN	4	FACU	Nt Tree
Populus tremuloides	QUAKING ASPEN	1	FAC	Nt Tree
Potamogeton pectinatus	SAGO PONDWEED	3	OBL	Nt P-Forb
Potentilla fruticosa	SHRUBBY CINQUEFOIL	10	FACW	Nt Shrub
Potentilla simplex	OLD FIELD CINQUEFOIL	2	FACU-	Nt P-Forb
Prenanthes alba	WHITE LETTUCE	5	FACU	Nt P-Forb
Prunella vulgaris	LAWN PRUNELLA	0	FAC	Nt P-Forb
Prunus serotina	WILD BLACK CHERRY	2	FACU	Nt Tree
Prunus virginiana	CHOKE CHERRY	2	FAC-	Nt Shrub
Pteridium aquilinum	BRACKEN FERN	0	FACU	Nt Fern
Pycnanthemum virginianum	COMMON MOUNTAIN MINT	5	FACW+	Nt P-Forb
Quercus alba	WHITE OAK	5	FACU	Nt Tree
Quercus bicolor	SWAMP WHITE OAK	8	FACW+	Nt Tree
Quercus ellipsoidalis	HILL'S OAK	4	UPL	Nt Tree
Quercus imbricaria	SHINGLE OAK	5	FAC-	Nt Tree

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Quercus macrocarpa	BUR OAK	5	FAC-	Nt Tree
Quercus muehlenbergii	CHINQUAPIN OAK	5	UPL	Nt Tree
Quercus palustris	PIN OAK	8	FACW	Nt Tree
Quercus rubra	RED OAK	5	FACU	Nt Tree
Quercus velutina	BLACK OAK	6	UPL	Nt Tree
Ranunculus abortivus	SMALL FLOWERED BUTTERCUP	0	FACW-	Nt A-Forb
Ranunculus flabellaris	YELLOW WATER CROWFOOT	10	OBL	Nt P-Forb
Ranunculus hispidus	SWAMP BUTTERCUP	5	FAC	Nt P-Forb
Ranunculus recurvatus	HOOKED CROWFOOT	5	FACW	Nt A-Forb
Rhus glabra	SMOOTH SUMAC	2	UPL	Nt Tree
Rhus typhina	STAGHORN SUMAC	2	UPL	Nt Tree
Ribes americanum	WILD BLACK CURRANT	6	FACW	Nt Shrub
Ribes cynosbati	PRICKLY or WILD GOOSEBERRY	4	UPL	Nt Shrub
Rosa palustris	SWAMP ROSE	5	OBL	Nt Shrub
Rubus allegheniensis	COMMON BLACKBERRY	1	FACU+	Nt Shrub
Rubus flagellaris	NORTHERN DEWBERRY	1	FACU-	Nt Shrub
Rubus hispidus	SWAMP DEWBERRY	4	FACW	Nt Shrub
Rubus occidentalis	BLACK RASPBERRY	1	UPL	Nt Shrub
Rubus pubescens	DWARF RASPBERRY	4	FACW+	Nt P-Forb
Rubus strigosus	WILD RED RASPBERRY	2	FACW-	Nt Shrub
Rudbeckia fulgida	BLACK EYED SUSAN	9	OBL	Nt P-Forb
Rudbeckia hirta	BLACK EYED SUSAN	1	FACU	Nt P-Forb
Rudbeckia laciniata	CUT LEAVED CONEFLOWER	6	FACW+	Nt P-Forb
Rumex orbiculatus	GREAT WATER DOCK	9	OBL	Nt P-Forb
Rumex verticillatus	WATER DOCK	7	OBL	Nt P-Forb
Sagittaria latifolia	COMMON ARROWHEAD	1	OBL	Nt P-Forb
Salix amygdaloides	PEACH LEAVED WILLOW	3	FACW	Nt Tree
Salix bebbiana	BEBB'S WILLOW	1	FACW+	Nt Shrub
Salix discolor	PUSSY WILLOW	1	FACW	Nt Shrub
Salix exigua	SANDBAR WILLOW	1	OBL	Nt Shrub
Salix nigra	BLACK WILLOW	5	OBL	Nt Tree
Salix petiolaris	SLENDER WILLOW	1	FACW+	Nt Shrub
Sambucus canadensis	ELDERBERRY	3	FACW-	Nt Shrub
Sambucus racemosa	RED BERRIED ELDER	3	FACU+	Nt Shrub
Samolus parviflorus	WATER PIMPERNEL	5	OBL	Nt P-Forb
Sanguinaria canadensis	BLOODROOT	5	FACU-	Nt P-Forb
Sanicula gregaria	BLACK SNAKEROOT	2	FAC+	Nt P-Forb
Sanicula marilandica	BLACK SNAKEROOT	4	FACU	Nt P-Forb
Sassafras albidum	SASSAFRAS	5	FACU	Nt Tree
Saururus cernuus	LIZARD'S TAIL	9	OBL	Nt P-Forb
Saxifraga pensylvanica	SWAMP SAXIFRAGE	10	OBL	Nt P-Forb
Schoenoplectus tabernaemontani	SOFTSTEM BULRUSH	4	OBL	Nt P-Sedge
Scirpus atrovirens	BULRUSH	3	OBL	Nt P-Sedge
Scirpus cyperinus	WOOL GRASS	5	OBL	Nt P-Sedge
Scirpus pendulus	BULRUSH	3	OBL	Nt P-Sedge
Scrophularia marilandica	LATE FIGWORT	5	FACU-	Nt P-Forb
Scutellaria galericulata	COMMON SKULLCAP	5	OBL	Nt P-Forb
Scutellaria lateriflora	MAD DOG SKULLCAP	5	OBL	Nt P-Forb
Senecio aureus	GOLDEN RAGWORT	5	FACW	Nt P-Forb
Sicyos angulatus	BUR CUCUMBER	2	FACW-	Nt A-Forb
Sisyrinchium albidum	COMMON BLUE EYED GRASS	7	FACU	Nt P-Forb

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Sium suave	WATER PARSNIP	5	OBL	Nt P-Forb
Smilacina racemosa	FALSE SPIKENARD	5	FACU	Nt P-Forb
Smilacina stellata	STARRY FALSE SOLOMON SEAL	5	FAC-	Nt P-Forb
Smilax ecirrhata	UPRIGHT CARRION FLOWER	6	UPL	Nt P-Forb
Smilax illinoensis	CARRION FLOWER	4	UPL	Nt P-Forb
Smilax tamnoides	BRISTLY GREEN BRIER	5	FAC	Nt W-Vine
Solidago altissima	TALL GOLDENROD	1	FACU	Nt P-Forb
Solidago caesia	BLUE STEMMED GOLDENROD	7	FACU	Nt P-Forb
Solidago canadensis	CANADA GOLDENROD	1	FACU	Nt P-Forb
Solidago flexicaulis	BROAD LEAVED GOLDENROD	6	FACU	Nt P-Forb
Solidago gigantea	LATE GOLDENROD	3	FACW	Nt P-Forb
Solidago nemoralis	OLD FIELD GOLDENROD	2	UPL	Nt P-Forb
Solidago patula	SWAMP GOLDENROD	6	OBL	Nt P-Forb
Solidago rugosa	ROUGH GOLDENROD	3	FAC+	Nt P-Forb
Sparganium eurycarpum	COMMON BUR REED	5	OBL	Nt P-Forb
Sphenopholis intermedia	SLENDER WEDGEGRASS	4	FAC	Nt P-Grass
Spiraea alba	MEADOWSWEET	4	FACW+	Nt Shrub
Spiranthes cernua	NODDING LADIES' TRESSES	4	FACW-	Nt P-Forb
Spirodela polyrhiza	GREAT DUCKWEED	6	OBL	Nt A-Forb
Stachys tenuifolia	SMOOTH HEDGE NETTLE	5	OBL	Nt P-Forb
Staphylea trifolia	BLADDERNUT	9	FAC	Nt Shrub
Stellaria longifolia	LONG LEAVED CHICKWEED	5	FACW+	Nt P-Forb
Symphoricarpos albus	SNOWBERRY	5	FACU-	Nt Shrub
Symplocarpus foetidus	SKUNK CABBAGE	6	OBL	Nt P-Forb
Teucrium canadense	WOOD SAGE	4	FACW-	Nt P-Forb
Thalictrum dasycarpum	PURPLE MEADOW RUE	3	FACW-	Nt P-Forb
Thalictrum dioicum	EARLY MEADOW RUE	6	FACU+	Nt P-Forb
Thelypteris noveboracensis	NEW YORK FERN	5	FAC+	Nt Fern
Thelypteris palustris	MARSH FERN	2	FACW+	Nt Fern
Thuja occidentalis	ARBOR VITAE	4	FACW	Nt Tree
Tilia americana	BASSWOOD	5	FACU	Nt Tree
Toxicodendron radicans	POISON IVY	2	FAC+	Nt W-Vine
Tradescantia ohiensis	COMMON SPIDERWORT	5	FACU+	Nt P-Forb
Trillium cernuum	NODDING TRILLIUM	5	FAC	Nt P-Forb
Trillium flexipes	DROOPING TRILLIUM	7	FAC-	Nt P-Forb
Trillium grandiflorum	COMMON TRILLIUM	5	UPL	Nt P-Forb
Trillium nivale	SNOW TRILLIUM	10	UPL	Nt P-Forb
Triosteum aurantiacum	HORSE GENTIAN	5	UPL	Nt P-Forb
Triosteum perfoliatum	HORSE GENTIAN	5	UPL	Nt P-Forb
Typha latifolia	BROAD LEAVED CATTAIL	1	OBL	Nt P-Forb
Ulmus americana	AMERICAN ELM	1	FACW-	Nt Tree
Ulmus rubra	SLIPPERY ELM	2	FAC	Nt Tree
Urtica dioica	NETTLE	1	FAC+	Nt P-Forb
Uvularia grandiflora	BELLWORT	5	UPL	Nt P-Forb
Vaccinium angustifolium	BLUEBERRY	4	FACU	Nt Shrub
Verbena urticifolia	WHITE VERVAIN	4	FAC+	Nt P-Forb
Verbesina alternifolia	WINGSTEM	4	FACW	Nt P-Forb
Vernonia missurica	MISSOURI IRONWEED	4	FAC+	Nt P-Forb
Veronicastrum virginicum	CULVER'S ROOT	8	FAC	Nt P-Forb
Viburnum acerifolium	MAPLE LEAVED ARROW WOOD	6	UPL	Nt Shrub
Viburnum dentatum	SMOOTH ARROW WOOD	6	FACW-	Nt Shrub

Appendix V. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Viburnum lentago	NANNYBERRY	4	FAC+	Nt Shrub
Viburnum opulus var. americanum	HIGHBUSH CRANBERRY	5	FACW	Nt Shrub
Viola blanda	SWEET WHITE VIOLET	5	FACW-	Nt P-Forb
Viola nephrophylla	NORTHERN BOG VIOLET	8	FACW+	Nt P-Forb
Viola pubescens	YELLOW VIOLET	4	FACU-	Nt P-Forb
Viola sororia	COMMON BLUE VIOLET	1	FAC-	Nt P-Forb
Viola striata	CREAM VIOLET	5	FACW	Nt P-Forb
Vitis riparia	RIVERBANK GRAPE	3	FACW-	Nt W-Vine
Wolffia columbiana	COMMON WATER MEAL	5	OBL	Nt A-Forb
Zanthoxylum americanum	PRICKLY ASH	3	UPL	Nt Shrub
Zizia aurea	GOLDEN ALEXANDERS	6	FAC+	Nt P-Forb

Appendix VI. Adventive plant species observed during the riparian ecosystem study. Coefficients of conservatism (C), wetness classes and physiognomy descriptions are provided for each species.

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
BERTEROA INCANA	HOARY ALYSSUM	0	UPL	Ad A-Forb
FAGOPYRUM ESCULENTUM	BUCKWHEAT	0	UPL	Ad A-Forb
POLYGONUM PERSICARIA	LADY'S THUMB	0	FACW	Ad A-Forb
STELLARIA MEDIA	COMMON CHICKWEED	0	FACU	Ad A-Forb
TORILIS JAPONICA	HEDGE PARSLEY	0	UPL	Ad A-Forb
VERONICA CHAMAEDRYS	GERMANDER SPEEDWELL	0	UPL	Ad A-Forb
XANTHIUM STRUMARIUM	COMMON COCKLEBUR	0	FAC	Ad A-Forb
APERA SPICA-VENTI	APERA	0	UPL	Ad A-Grass
ECHINOCHLOA CRUSGALLI	BARNYARD GRASS	0	FACW	Ad A-Grass
POA ANNUA	ANNUAL BLUEGRASS	0	FAC-	Ad A-Grass
ALLIARIA PETIOLATA	GARLIC MUSTARD	0	FAC	Ad B-Forb
ARCTIUM MINUS	COMMON BURDOCK	0	UPL	Ad B-Forb
BARBAREA VULGARIS	YELLOW ROCKET	0	FAC	Ad B-Forb
CENTAUREA MACULOSA	SPOTTED BLUET	0	UPL	Ad B-Forb
CIRSIUM VULGARE	BULL THISTLE	0	FACU-	Ad B-Forb
DAUCUS CAROTA	QUEEN ANNE'S LACE	0	UPL	Ad B-Forb
VERBASCUM THAPSUS	COMMON MULLEIN	0	UPL	Ad B-Forb
ASPARAGUS OFFICINALIS	ASPARAGUS	0	FACU	Ad P-Forb
CIRSIUM ARVENSE	CANADIAN THISTLE	0	FACU	Ad P-Forb
GLECHOMA HEDERACEA	GROUND IVY	0	FACU	Ad P-Forb
HESPERIS MATRONALIS	DAME'S ROCKET	0	UPL	Ad P-Forb
HIERACIUM PILOSELLOIDES	GLAUCOUS KING DEVIL	0	UPL	Ad P-Forb
HYPERICUM PERFORATUM	COMMON ST. JOHN'S WORT	0	UPL	Ad P-Forb
IRIS PSEUDACORUS	YELLOW FLAG	0	OBL	Ad P-Forb
LATHYRUS TUBEROSUS	TUBEROUS VETCHLING	0	UPL	Ad P-Forb
LEONURUS CARDIACA	MOTHERWORT	0	UPL	Ad P-Forb
LYSIMACHIA NUMMULARIA	MONEYWORT	0	FACW+	Ad P-Forb
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE	0	OBL	Ad P-Forb
MENTHA PIPERITA	PEPPERMINT	0	OBL	Ad P-Forb
MYOSOTIS SCORPIOIDES	FORGET ME NOT	0	OBL	Ad P-Forb
PLANTAGO MAJOR	COMMON PLANTAIN	0	FAC+	Ad P-Forb
POTAMOGETON CRISPUS	PONDWEED	0	OBL	Ad P-Forb
RANUNCULUS ACRIS	TALL or COMMON BUTTERCUP	0	FACW-	Ad P-Forb
RUMEX ACETOSELLA	SHEEP SORREL	0	FAC	Ad P-Forb
RUMEX CRISPUS	CURLY DOCK	0	FAC+	Ad P-Forb
SOLANUM CAROLINENSE	HORSE NETTLE	0	FACU-	Ad P-Forb
SOLANUM DULCAMARA	BITTERSWEET NIGHTSHADE	0	FAC	Ad P-Forb
TARAXACUM OFFICINALE	COMMON DANDELION	0	FACU	Ad P-Forb
AGROSTIS GIGANTEA	REDTOP	0	FAC	Ad P-Grass
BROMUS INERMIS	SMOOTH BROME	0	UPL	Ad P-Grass
DACTYLIS GLOMERATA	ORCHARD GRASS	0	FACU	Ad P-Grass
FESTUCA ARUNDINACEA	TALL FESCUE	0	FACU+	Ad P-Grass
NASTURTIUM OFFICINALE	WATERCRESS	0	OBL	Ad P-Grass
PHLEUM PRATENSE	TIMOTHY	0	FACU	Ad P-Grass
POA COMPRESSA	CANADA BLUEGRASS	0	FACU+	Ad P-Grass
POA PRATENSIS	KENTUCKY BLUEGRASS	0	FAC-	Ad P-Grass
POA TRIVIALIS	BLUEGRASS	0	FACW	Ad P-Grass
BERBERIS THUNBERGII	JAPANESE BARBERRY	0	FACU-	Ad Shrub
ELAEAGNUS UMBELLATA	AUTUMN OLIVE	0	FACU	Ad Shrub
EUONYMUS EUROPAEA	SPINDLE TREE	0	UPL	Ad Shrub
LIGUSTRUM VULGARE	COMMON PRIVET	0	FAC-	Ad Shrub

Appendix VI. *Cont.*

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
LONICERA MAACKII	AMUR HONEYSUCKLE	0	UPL	Ad Shrub
LONICERA MORROWII	MORROW HONEYSUCKLE	0	UPL	Ad Shrub
LONICERA TATARICA	SMOOTH TARTARIAN HONEYSUCKLE	0	FACU	Ad Shrub
RHAMNUS FRANGULA	GLOSSY BUCKTHORN	0	FAC+	Ad Shrub
ROSA MULTIFLORA	MULTIFLORA ROSE	0	FACU	Ad Shrub
VIBURNUM OPULUS	EUROPEAN HIGHBUSH CRANBERRY	0	FAC	Ad Shrub
ACER PLATANOIDES	NORWAY MAPLE	0	UPL	Ad Tree
AILANTHUS ALTISSIMA	TREE OF HEAVEN	0	UPL	Ad Tree
CATALPA SPECIOSA	NORTHERN CATALPA	0	FACU	Ad Tree
MALUS PUMILA	APPLE	0	UPL	Ad Tree
MORUS ALBA	WHITE MULBERRY	0	FAC	Ad Tree
PICEA ABIES	NORWAY SPRUCE	0	UPL	Ad Tree
PINUS PONDEROSA	PONDEROSA PINE	0	UPL	Ad Tree
PINUS SYLVESTRIS	SCOTCH PINE	0	UPL	Ad Tree
PRUNUS AVIUM	SWEET CHERRY	0	UPL	Ad Tree
RHAMNUS CATHARTICA	COMMON BUCKTHORN	0	FACU	Ad Tree
ROBINIA PSEUDOACACIA	BLACK LOCUST	0	FACU-	Ad Tree

Appendix VII. Presence/absence data and species richness of frogs observed at 18 riparian study sites representing three riparian buffer width classes (<125m, 125-250m, 250-500m) in 2001.

Frog Species		<125m						125-250m						250-500m					
Common name	Scientific Name	LG*	MR	PR	RC	SR	SJ	LG	MR	PR	RC	SR	TR	KZ	MR*	PR	SC	SR*	RR
Wood Frog	*Rana sylvatica*	C	V			V	V	C, V	V	V	C, V	V	V	V	C	C, V	V		
Northern Spring Peeper	*Pseudacris crucifer crucifer*	C					C	C	C	C	C	C	C	C	C	C		C	C
Western Chorus Frog	*Pseudacris triseriata triseriata*		C					C	C		C	C	C	C	C			C	C
Eastern Gray Treefrog	*Hyla versicolor*	C	C			C, I		C		C	C		C	I	C	C, I	C		
Northern Leopard Frog	*Rana pipiens*	C							C				C, V		C, I				
Eastern American Toad	*Bufo americanus americanus*		C	V, I	V	V	C	V	C		C		V	V, I	C, I	C, V			
Green frog	*Rana clamitans melanota*	C	C	V		V, I		C	C	V	C	C, V, I	C		C, I	C, V	C	C	
Bullfrog	*Rana catesbeiana*											C							
Additional herp species observed during visual encounter or aquatic surveys:																			
Common Snapping Turtle	*Chelydra serpentina serpentina*			I								I			I		I		
Common Musk Turtle	*Sternotherus odoratus*											I							
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*														I				
Northern Water Snake	*Nerodia sipedon sipedon*														I				
Total # of frog species (call surveys only)**		5	4	0	0	1	2	5	5	2	6	4	5	2	7	5	2	3	2
Total # of frog species (call and visual surveys)**		5	5	2	1	3	3	6	6	4	6	5	7	4	7	5	3	3	2

*Visual encounter surveys were not conducted at these sites due to unsuitable weather or site conditions.
**Total does not include incidental species.

Appendix VIII.Bird species observed during breeding surveys (June, 2001). "X" = inside 50m radius, "O" = outside 50m radius. Incidental sightings by other research team members are indicated by "I."

	Maple			Pine			Shiawassee			Red Cedar		Looking Glass		Sycamore	St. Joseph	Thornapple	Raisin	Kalamazoo
Species Common Name	<125	125-250	>250	<125	125-250	>250	<125	125-250	>250	<125	125-250	<125	125-250	>250	<125	125-250	>250	>250
Green Heron				I			I											
Great Blue Heron	I	I			O	I		I		I	I	I						
Sandhill Crane			O															
Canada Goose			O															
Mallard			I	I		I	I	I	I	X	O	X	I	I				
Wood Duck				O		O					O	I	I					
Turkey Vulture									O									
Red-tailed Hawk	I	O				O						X				O		
American Kestrel	I																	
Wild Turkey					I													
Mourning Dove	O	O	O															O
Black-billed Cuckoo			O															
Yellow-billed Cuckoo																		O
Great Horned Owl		I											I					
Barred Owl						O												
Ruby-throated Hummingbird						O			X		O						X	
Belted Kingfisher			O	I	X			X	X	X	O	I	X	I	O	I		
Red-bellied Woodpecker	X	X	X		X	X	X	O	X	X	X	X	X		X	X	O	X
Northern Flicker			X			X							X		O	O		X
Downy Woodpecker	O	X	O	X	O	O	X	X			X	X	X	X	O			
Hairy Woodpecker						X		X		X	X		X			X	X	X
Great-crested Flycatcher	X	O	X	X	X	O		X	O	X	X	X	O	O	X	X	X	X
Eastern Wood-Pewee	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eastern Phoebe	X		X		O	O			X		O		O	X			X	X
Least Flycatcher									X									
Acadian Flycatcher							X											
Blue Jay	X	O			X	X		X	O	X	X	X	X	O		O	X	O
American Crow	O	O	O	O	O	X	O	O	O	X	O	X	O	X	O	X	O	O
Tufted Titmouse	X	O	X		O	O		X			X	X	X	O	X	X	X	X
Black-capped Chickadee	O	O	X	X		X	O	X	X	X	X	X	X	X	O	X	X	X
Brown Creeper											X						X	
White-breasted Nuthatch	O	X	X	X	X	X	X	X		X	X	O	X	O	X	O	X	X
House Wren								O				O			X	O		
Blue-gray Gnatcatcher					X			X	X									
Wood Thrush	X			O	O		O	X	X			X		O				
Veery									O				O				X	X
Hermit Thrush	X		O		O							X		X	O			O
American Robin	X	O	X	X		X	X		X		O	X	X	X	X	X	O	X
Gray Catbird			O		X			X	X	X	X					X		
Cedar Waxwing		X										X						
Yellow-throated Vireo							O	X	X		O	O				O		
Red-eyed Vireo	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Warbling Vireo	X	O																
Yellow Warbler	O		O						X		O		X			O		O
Mourning Warbler	X																	
Ovenbird						O												
Common Yellowthroat			X															X
American Redstart	X		X						X						X			
Rose-breated Groesbeak		O			X			X						X		X		
Northern Cardinal	O	X	X	O	X	O	X	X	X	X	X	X	X	X	X	X	X	O
Indigo Bunting		O		O		X		X	X		X					X		X
Song Sparrow	X	O	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Field Sparrow														O				O
Chipping Sparrow			O												O	O		
Red-winged Blackbird			O				O							O		O		
Brown-headed Cowbird	X	O	X	X			X	X					X			X		
Common Grackle	X	X	X			X						X	X		X	O	X	O
Baltimore Oriole	X		X			O		X	X			X				X	X	X
Scarlet Tanager		X																
American Goldfinch	X	X	X		O	X	X			X	X	O	X		X	X	X	X
Total # of species	28	25	31	17	21	27	17	25	25	15	26	26	25	20	20	28	20	26

Appendix IX. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of agricultural land covers within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in dark gray (p<0.01). Community parameter descriptions are provided within the report text.

Land-scape Context	Buffer Width (m)	TASR		HQI		MSR		RAIU		RATU		MBTI		MCPUE		FSR		FIBI		RAIF		FCPUE	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.24	0.23	-0.23	0.25	0.01	0.97	-0.06	0.77	0.07	0.72	-0.19	0.35	-0.05	0.82	-0.02	0.91	-0.18	0.38	-0.45	0.02	0.15	0.45
Local	60	0.49	0.01	-0.03	0.89	0.03	0.90	0.13	0.51	-0.07	0.73	-0.31	0.11	-0.01	0.97	0.12	0.56	0.06	0.77	-0.24	0.23	0.35	0.07
Local	120	0.60	0.001	0.10	0.61	0.12	0.57	0.13	0.52	0.04	0.83	-0.20	0.31	0.02	0.93	0.26	0.19	0.20	0.33	-0.10	0.61	0.33	0.09
Local	240	0.60	0.001	0.12	0.55	0.11	0.58	0.13	0.51	0.03	0.90	-0.22	0.27	0.04	0.84	0.30	0.13	0.29	0.15	-0.06	0.78	0.27	0.18
Local	480	0.59	0.001	0.06	0.76	0.06	0.75	0.12	0.54	-0.04	0.83	-0.30	0.13	0.04	0.85	0.29	0.14	0.29	0.14	-0.08	0.70	0.21	0.30
Local	960	0.50	0.008	0.00	1.00	0.02	0.91	0.17	0.41	-0.13	0.52	-0.40	0.04	0.01	0.97	0.25	0.20	0.29	0.14	-0.07	0.72	0.26	0.20
U/S-1	30	0.33	0.10	0.27	0.18	-0.01	0.97	0.27	0.18	-0.30	0.13	-0.31	0.12	0.04	0.83	0.16	0.42	0.19	0.34	-0.10	0.62	0.23	0.25
U/S-1	60	0.25	0.21	0.09	0.64	0.06	0.78	0.06	0.75	-0.28	0.16	-0.23	0.25	0.17	0.39	0.07	0.72	0.06	0.76	-0.16	0.43	0.26	0.19
U/S-1	120	0.26	0.18	0.02	0.92	0.09	0.66	-0.07	0.74	-0.27	0.18	-0.23	0.26	0.17	0.40	0.01	0.98	0.03	0.88	-0.18	0.36	0.23	0.26
U/S-1	240	0.21	0.29	0.13	0.52	-0.03	0.90	-0.06	0.78	-0.31	0.12	-0.14	0.48	0.21	0.30	-0.15	0.46	0.03	0.90	-0.05	0.82	0.33	0.09
U/S-1	480	0.28	0.16	-0.12	0.57	0.09	0.66	-0.12	0.54	-0.29	0.14	-0.32	0.10	0.24	0.23	-0.09	0.67	0.07	0.72	-0.13	0.51	0.29	0.14
U/S-1	960	0.28	0.16	-0.12	0.57	0.17	0.40	-0.06	0.76	-0.31	0.12	-0.36	0.06	0.30	0.13	-0.05	0.81	0.15	0.47	-0.10	0.62	0.30	0.13
U/S-2	30	0.32	0.11	0.27	0.18	0.07	0.74	0.36	0.06	-0.40	0.04	-0.25	0.21	0.32	0.10	0.05	0.81	0.07	0.74	0.04	0.85	0.14	0.48
U/S-2	60	0.32	0.10	0.24	0.24	0.13	0.51	0.36	0.07	-0.43	0.03	-0.32	0.10	0.36	0.07	0.14	0.50	0.06	0.75	-0.03	0.90	0.13	0.51
U/S-2	120	0.26	0.19	0.18	0.37	0.10	0.61	0.04	0.85	-0.27	0.17	-0.10	0.63	0.33	0.10	0.05	0.79	0.09	0.66	-0.04	0.85	0.05	0.79
U/S-2	240	0.37	0.06	0.16	0.43	0.11	0.59	0.12	0.56	-0.31	0.12	-0.22	0.26	0.52	0.006	-0.03	0.88	0.09	0.65	0.04	0.85	0.21	0.30
U/S-2	480	0.33	0.09	0.09	0.67	0.18	0.38	0.21	0.29	-0.29	0.14	-0.24	0.23	0.59	0.001	0.03	0.88	0.11	0.60	0.12	0.56	0.20	0.33
U/S-2	960	0.37	0.06	0.17	0.39	0.23	0.24	0.28	0.16	-0.32	0.10	-0.31	0.12	0.58	0.002	0.13	0.53	0.22	0.28	0.12	0.55	0.15	0.47
U/S-3	30	0.17	0.40	-0.03	0.88	-0.01	0.97	0.02	0.93	-0.35	0.08	-0.45	0.02	0.05	0.80	0.15	0.47	0.28	0.16	-0.01	0.98	0.42	0.03
U/S-3	60	0.26	0.20	0.00	1.00	0.10	0.64	0.04	0.83	-0.32	0.11	-0.39	0.05	0.15	0.45	0.21	0.30	0.32	0.11	-0.02	0.93	0.40	0.04
U/S-3	120	0.33	0.10	-0.05	0.79	0.13	0.51	0.04	0.83	-0.23	0.25	-0.33	0.09	0.23	0.24	0.21	0.29	0.28	0.15	-0.06	0.76	0.35	0.07
U/S-3	240	0.34	0.08	-0.13	0.50	0.05	0.80	0.06	0.75	-0.27	0.18	-0.38	0.05	0.27	0.17	0.13	0.50	0.27	0.18	-0.09	0.65	0.35	0.08
U/S-3	480	0.35	0.08	-0.22	0.27	0.04	0.84	0.08	0.71	-0.33	0.10	-0.44	0.02	0.30	0.12	0.13	0.52	0.32	0.11	-0.06	0.77	0.37	0.06
U/S-3	960	0.36	0.07	-0.19	0.35	0.08	0.68	0.09	0.67	-0.36	0.07	-0.45	0.02	0.27	0.18	0.18	0.36	0.42	0.03	0.04	0.86	0.38	0.05

Appendix IX. *Cont.*

Land-scape Context	Buffer Width (m)	BNSR		INBI		EPT		RAIB		BSR		HSR		#Zone		CTV		BA		NTS	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.21	0.31	0.10	0.61	0.19	0.33	0.07	0.73	-0.10	0.70	0.22	0.37	-0.01	0.96	0.18	0.37	-0.09	0.67	-0.30	0.13
Local	60	0.49	0.009	0.08	0.69	0.42	0.03	0.24	0.22	-0.18	0.49	0.18	0.48	-0.10	0.61	0.01	0.97	-0.07	0.71	-0.21	0.30
Local	120	0.58	0.002	0.04	0.85	0.49	0.009	0.26	0.19	-0.09	0.72	0.12	0.64	-0.23	0.26	-0.09	0.67	-0.09	0.66	-0.21	0.29
Local	240	0.57	0.002	0.11	0.60	0.47	0.01	0.30	0.12	-0.06	0.81	0.17	0.51	-0.24	0.24	-0.10	0.61	-0.21	0.30	-0.24	0.23
Local	480	0.57	0.002	0.13	0.51	0.50	0.008	0.38	0.05	-0.09	0.72	0.24	0.33	-0.16	0.44	-0.05	0.82	-0.28	0.15	-0.20	0.33
Local	960	0.50	0.008	0.17	0.39	0.43	0.03	0.40	0.04	-0.10	0.69	0.23	0.35	-0.06	0.78	-0.07	0.72	-0.34	0.08	-0.20	0.33
U/S-1	30	0.27	0.17	-0.14	0.48	0.32	0.11	0.03	0.87	-0.03	0.92	0.09	0.72	-0.31	0.12	-0.27	0.18	-0.07	0.73	-0.17	0.41
U/S-1	60	0.20	0.33	-0.15	0.45	0.32	0.10	0.07	0.73	0.03	0.90	0.17	0.50	-0.16	0.42	-0.10	0.63	0.03	0.90	-0.09	0.66
U/S-1	120	0.21	0.29	-0.04	0.84	0.30	0.13	0.19	0.34	0.04	0.87	0.29	0.25	-0.12	0.56	-0.07	0.75	0.06	0.78	-0.06	0.76
U/S-1	240	0.24	0.22	0.19	0.34	0.21	0.29	0.15	0.45	0.18	0.49	0.15	0.55	-0.23	0.26	-0.11	0.58	0.20	0.31	0.05	0.80
U/S-1	480	0.27	0.18	0.10	0.64	0.20	0.31	0.33	0.09	0.08	0.78	0.40	0.10	-0.11	0.59	-0.13	0.53	0.13	0.51	-0.06	0.78
U/S-1	960	0.25	0.20	0.11	0.60	0.16	0.42	0.33	0.09	0.12	0.64	0.43	0.08	-0.10	0.61	-0.14	0.49	0.09	0.66	-0.13	0.51
U/S-2	30	0.24	0.22	-0.15	0.46	0.37	0.06	0.05	0.80	-0.21	0.42	0.02	0.93	-0.21	0.29	-0.20	0.32	0.10	0.64	0.07	0.74
U/S-2	60	0.22	0.26	-0.10	0.61	0.34	0.08	0.05	0.81	-0.17	0.52	0.09	0.71	-0.23	0.26	-0.19	0.34	0.02	0.90	-0.02	0.94
U/S-2	120	0.18	0.38	0.01	0.98	0.26	0.20	0.05	0.80	-0.16	0.55	0.09	0.73	-0.21	0.30	-0.23	0.25	0.07	0.73	0.10	0.63
U/S-2	240	0.34	0.08	0.06	0.77	0.33	0.09	0.26	0.19	-0.06	0.81	0.29	0.25	-0.19	0.36	-0.25	0.22	0.11	0.59	-0.02	0.94
U/S-2	480	0.31	0.11	0.22	0.27	0.23	0.25	0.23	0.25	-0.08	0.76	0.21	0.41	-0.25	0.20	-0.33	0.10	0.01	0.96	-0.08	0.71
U/S-2	960	0.35	0.08	0.13	0.51	0.30	0.13	0.32	0.11	0.03	0.90	0.24	0.33	-0.16	0.43	-0.30	0.13	-0.04	0.84	-0.18	0.36
U/S-3	30	0.07	0.72	-0.08	0.70	0.25	0.22	0.15	0.47	-0.15	0.58	0.07	0.80	-0.06	0.76	-0.09	0.68	0.01	0.97	-0.02	0.92
U/S-3	60	0.14	0.48	-0.13	0.52	0.28	0.16	0.07	0.72	-0.14	0.59	0.10	0.68	-0.19	0.36	-0.19	0.35	0.19	0.34	0.04	0.86
U/S-3	120	0.20	0.32	-0.13	0.53	0.33	0.10	0.14	0.50	-0.13	0.63	0.16	0.52	-0.18	0.36	-0.17	0.41	0.20	0.32	0.03	0.90
U/S-3	240	0.28	0.17	0.02	0.91	0.31	0.11	0.27	0.17	-0.13	0.62	0.23	0.36	-0.18	0.37	-0.15	0.45	0.15	0.47	-0.02	0.91
U/S-3	480	0.30	0.12	0.10	0.61	0.30	0.13	0.34	0.08	-0.15	0.57	0.21	0.41	-0.17	0.40	-0.20	0.32	0.06	0.76	-0.07	-0.13
U/S-3	960	0.32	0.11	0.10	0.34	0.30	0.13	0.37	0.06	-0.02	0.93	0.21	0.41	-0.17	0.40	-0.23	0.25	0.02	0.92	0.72	0.52

Appendix IX. *Cont.*

Land-scape Context	Buffer Width (m)	DBH		USSt		USSp		GCS		TNPS		TAPS		TPS		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.27	0.17	-0.23	0.24	-0.11	0.57	-0.10	0.61	-0.49	0.01	-0.18	0.36	-0.48	0.01	-0.21	0.30	0.21	0.30	-0.48	0.01
Local	60	0.33	0.09	-0.13	0.53	-0.08	0.68	-0.01	0.94	-0.51	0.006	-0.25	0.21	-0.52	0.006	-0.13	0.53	0.13	0.53	-0.53	0.005
Local	120	0.28	0.15	-0.11	0.59	-0.17	0.41	-0.15	0.46	-0.58	0.001	-0.19	0.35	-0.58	0.002	-0.23	0.25	0.23	0.25	-0.57	0.002
Local	240	0.29	0.14	-0.09	0.64	-0.15	0.45	-0.13	0.52	-0.59	0.001	-0.25	0.22	-0.60	0.001	-0.18	0.36	0.18	0.36	-0.56	0.002
Local	480	0.23	0.25	-0.06	0.79	-0.07	0.74	-0.03	0.88	-0.55	0.003	-0.25	0.21	-0.56	0.003	-0.15	0.45	0.15	0.45	-0.53	0.004
Local	960	0.04	0.84	-0.02	0.92	0.05	0.81	0.13	0.53	-0.47	0.01	-0.19	0.33	-0.47	0.01	-0.16	0.42	0.16	0.42	-0.50	0.006
U/S-1	30	0.06	0.78	-0.52	0.006	-0.35	0.07	-0.06	0.77	-0.29	0.15	-0.11	0.58	-0.31	0.11	-0.07	0.73	0.07	0.73	-0.22	0.27
U/S-1	60	0.00	1.00	-0.37	0.05	-0.24	0.23	-0.25	0.21	-0.18	0.37	0.09	0.66	-0.18	0.38	-0.23	0.26	0.23	0.26	-0.12	0.55
U/S-1	120	0.08	0.68	-0.39	0.04	-0.26	0.19	-0.29	0.14	-0.23	0.25	-0.02	0.94	-0.23	0.25	-0.20	0.33	0.20	0.33	-0.17	0.41
U/S-1	240	0.26	0.19	-0.32	0.11	-0.20	0.33	-0.17	0.40	-0.20	0.31	-0.13	0.52	-0.22	0.27	-0.02	0.93	0.02	0.93	-0.09	0.66
U/S-1	480	0.12	0.56	-0.40	0.04	-0.25	0.22	-0.21	0.29	-0.29	0.14	-0.28	0.16	-0.32	0.11	0.00	1.00	0.00	1.00	-0.25	0.20
U/S-1	960	0.16	0.44	-0.36	0.06	-0.21	0.29	-0.1	0.62	-0.28	0.15	-0.34	0.09	-0.31	0.11	0.06	0.77	-0.06	0.77	-0.26	0.19
U/S-2	30	0.20	0.32	-0.42	0.03	-0.27	0.17	-0.24	0.24	-0.20	0.32	-0.22	0.27	-0.23	0.25	0.04	0.84	-0.04	0.84	-0.13	0.54
U/S-2	60	0.14	0.50	-0.39	0.04	-0.22	0.26	-0.15	0.47	-0.20	0.31	-0.13	0.52	-0.22	0.28	-0.05	0.81	0.05	0.81	-0.13	0.51
U/S-2	120	0.13	0.51	-0.37	0.06	-0.27	0.17	-0.28	0.16	-0.24	0.23	-0.25	0.21	-0.29	0.15	0.00	1.00	0.00	1.00	-0.13	0.51
U/S-2	240	0.19	0.35	-0.46	0.02	-0.31	0.12	-0.18	0.37	-0.29	0.15	-0.38	0.05	-0.32	0.11	0.10	0.61	-0.10	0.61	-0.22	0.28
U/S-2	480	0.28	0.16	-0.40	0.04	-0.26	0.20	-0.11	0.58	-0.37	0.06	-0.42	0.03	-0.39	0.04	0.09	0.65	-0.09	0.65	-0.31	0.12
U/S-2	960	0.24	0.23	-0.41	0.03	-0.24	0.22	-0.03	0.87	-0.34	0.09	-0.47	0.01	-0.37	0.06	0.16	0.44	-0.16	0.44	-0.28	0.15
U/S-3	30	0.12	0.55	-0.04	0.85	0.01	0.97	-0.01	0.95	-0.08	0.70	0.00	1.00	-0.08	0.71	-0.04	0.83	0.04	0.83	0.00	1.00
U/S-3	60	0.10	0.63	-0.17	0.39	0.19	0.34	-0.13	0.53	-0.14	0.49	-0.06	0.76	-0.15	0.45	-0.04	0.84	0.04	0.84	-0.06	0.77
U/S-3	120	0.09	0.66	-0.21	0.28	0.20	0.32	-0.18	0.36	-0.16	0.44	-0.05	0.79	-0.16	0.43	-0.10	0.62	0.10	0.62	-0.08	0.68
U/S-3	240	0.19	0.34	-0.20	0.31	0.15	0.47	-0.14	0.49	-0.29	0.15	-0.21	0.29	-0.30	0.13	-0.04	0.86	0.04	0.86	-0.23	0.25
U/S-3	480	0.23	0.24	-0.36	0.07	-0.15	0.46	-0.08	0.69	-0.31	0.11	-0.29	0.15	-0.33	0.09	0.02	0.91	-0.02	0.91	-0.25	0.20
U/S-3	960	0.30	0.13	-0.35	0.08	-0.16	0.43	-0.1	0.64	-0.35	0.08	-0.30	0.13	-0.37	0.06	0.02	0.92	-0.02	0.92	-0.29	0.14

Appendix X. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of all modified land covers within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray ($p<0.005$). Community parameter descriptions are provided within the report text.

Landscape Context	Buffer Width (m)	TASR		HQI		MSR		RAIU		RATU		MBTI		MCPUE		FSR		FIBI		RAIF		FCPUE	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.16	0.42	-0.27	0.17	0.11	0.59	0.08	0.68	0.01	0.95	-0.18	0.38	0.07	0.72	0.13	0.53	-0.17	0.39	-0.29	0.15	0.33	0.09
Local	60	0.32	0.11	-0.03	0.87	0.19	0.36	0.25	0.21	0.01	0.97	-0.17	0.40	0.10	0.64	0.21	0.30	-0.04	0.83	-0.04	0.84	0.47	0.01
Local	120	0.43	0.03	-0.07	0.71	0.22	0.27	0.24	0.24	0.00	1.00	-0.21	0.29	0.09	0.65	0.32	0.10	0.04	0.86	0.04	0.83	0.46	0.02
Local	240	0.40	0.04	-0.01	0.96	0.16	0.43	0.18	0.37	0.00	1.00	-0.17	0.41	0.04	0.84	0.35	0.07	0.16	0.44	0.13	0.53	0.42	0.03
Local	480	0.44	0.02	-0.07	0.73	0.12	0.54	0.18	0.38	-0.01	0.95	-0.25	0.21	0.02	0.92	0.36	0.07	0.18	0.38	0.08	0.68	0.37	0.06
Local	960	0.42	0.03	-0.07	0.72	0.13	0.53	0.23	0.26	-0.04	0.84	-0.30	0.12	0.03	0.88	0.37	0.06	0.18	0.38	0.08	0.70	0.33	0.09
U/S-1	30	0.12	0.54	0.06	0.76	-0.04	0.86	0.35	0.07	-0.23	0.25	-0.22	0.28	-0.14	0.50	0.18	0.36	0.02	0.93	-0.05	0.82	0.23	0.26
U/S-1	60	0.03	0.89	-0.07	0.72	0.04	0.86	0.20	0.32	-0.19	0.36	-0.12	0.57	-0.06	0.77	0.16	0.44	-0.08	0.68	-0.14	0.48	0.30	0.13
U/S-1	120	-0.03	0.90	-0.15	0.45	0.10	0.62	0.12	0.55	-0.22	0.26	-0.15	0.45	-0.01	0.95	0.15	0.45	-0.10	0.61	-0.08	0.70	0.35	0.08
U/S-1	240	-0.02	0.93	-0.06	0.76	0.03	0.87	0.17	0.41	-0.26	0.19	-0.12	0.57	0.02	0.92	0.03	0.88	-0.13	0.54	0.07	0.72	0.49	0.01
U/S-1	480	-0.09	0.65	-0.31	0.13	0.00	1.00	0.07	0.73	-0.13	0.53	-0.23	0.26	-0.14	0.51	0.01	0.96	-0.18	0.37	-0.23	0.27	0.26	0.19
U/S-1	960	0.12	0.57	-0.23	0.24	0.10	0.61	0.14	0.50	-0.26	0.19	-0.31	0.11	0.00	1.00	0.13	0.52	-0.06	0.76	-0.03	0.87	0.46	0.02
U/S-2	30	-0.05	0.81	-0.11	0.60	0.00	1.00	0.36	0.06	-0.43	0.03	-0.30	0.13	0.08	0.69	0.08	0.69	-0.09	0.67	0.04	0.83	0.13	0.53
U/S-2	60	-0.06	0.79	-0.13	0.51	-0.01	0.95	0.30	0.13	-0.45	0.02	-0.33	0.09	0.15	0.47	0.07	0.71	-0.09	0.66	0.01	0.97	0.11	0.57
U/S-2	120	-0.07	0.74	-0.18	0.38	-0.05	0.80	0.23	0.25	-0.45	0.02	-0.31	0.11	0.14	0.49	0.03	0.90	-0.10	0.62	0.00	1.00	0.10	0.62
U/S-2	240	0.06	0.78	-0.09	0.67	0.07	0.72	0.29	0.15	-0.40	0.04	-0.32	0.11	0.26	0.20	0.09	0.67	-0.12	0.57	0.06	0.78	0.25	0.21
U/S-2	480	0.03	0.90	-0.13	0.53	0.08	0.69	0.31	0.12	-0.33	0.09	-0.26	0.19	0.24	0.23	0.12	0.56	-0.12	0.54	0.04	0.85	0.22	0.28
U/S-2	960	0.04	0.84	-0.08	0.70	0.13	0.52	0.31	0.12	-0.33	0.09	-0.25	0.20	0.25	0.20	0.13	0.52	-0.08	0.69	0.03	0.87	0.13	0.52
U/S-3	30	-0.14	0.49	-0.20	0.32	-0.19	0.34	-0.04	0.84	-0.25	0.20	-0.26	0.20	-0.15	0.45	-0.03	0.87	0.02	0.93	0.09	0.66	0.4	0.04
U/S-3	60	-0.07	0.73	-0.29	0.14	-0.12	0.56	-0.02	0.93	-0.23	0.25	-0.21	0.29	-0.10	0.62	0.01	0.94	0.02	0.91	0.04	0.83	0.4	0.04
U/S-3	120	-0.04	0.83	-0.32	0.11	-0.07	0.74	-0.04	0.86	-0.15	0.47	-0.19	0.36	-0.05	0.81	0.03	0.88	-0.03	0.87	-0.05	0.82	0.41	0.03
U/S-3	240	-0.03	0.9	-0.33	0.10	-0.02	0.90	0.02	0.94	-0.17	0.39	-0.21	0.29	0.02	0.92	0.04	0.85	-0.03	0.90	-0.03	0.90	0.41	0.03
U/S-3	480	-0.02	0.92	-0.37	0.06	-0.02	0.92	0.04	0.85	-0.17	0.39	-0.23	0.25	0.00	1.00	0.07	0.75	0.01	0.95	-0.01	0.97	0.37	0.06
U/S-3	960	-0.02	0.911	-0.38	0.05	-0.01	0.95	-0.02	0.94	-0.23	0.25	-0.25	0.20	-0.07	0.72	0.09	0.67	0.10	0.61	0.03	0.88	0.36	0.07

Appendix X. *Cont.*

Land-scape Context	Buffer Width (m)	TASR		HQI		MSR		RAIU		RATU		MBTI		MCPUE		FSR		FIBI		RAIF		FCPUE	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.16	0.42	-0.27	0.17	0.11	0.59	0.08	0.68	0.01	0.95	-0.18	0.38	0.07	0.72	0.13	0.53	-0.17	0.39	-0.29	0.15	0.33	0.09
Local	60	0.32	0.11	-0.03	0.87	0.19	0.36	0.25	0.21	0.01	0.97	-0.17	0.40	0.10	0.64	0.21	0.30	-0.04	0.83	-0.04	0.84	0.47	0.01
Local	120	0.43	0.03	-0.07	0.71	0.22	0.27	0.24	0.24	0.00	1.00	-0.21	0.29	0.09	0.65	0.32	0.10	0.04	0.86	0.04	0.83	0.46	0.02
Local	240	0.40	0.04	-0.01	0.96	0.16	0.43	0.18	0.37	0.00	1.00	-0.17	0.41	0.04	0.84	0.35	0.07	0.16	0.44	0.13	0.53	0.42	0.03
Local	480	0.44	0.02	-0.07	0.73	0.12	0.54	0.18	0.38	-0.01	0.95	-0.25	0.21	0.02	0.92	0.36	0.07	0.18	0.38	0.08	0.68	0.37	0.06
Local	960	0.42	0.03	-0.07	0.72	0.13	0.53	0.23	0.26	-0.04	0.84	-0.30	0.12	0.03	0.88	0.37	0.06	0.18	0.38	0.08	0.70	0.33	0.09
U/S-1	30	0.12	0.54	0.06	0.76	-0.04	0.86	0.35	0.07	-0.23	0.25	-0.22	0.28	-0.14	0.50	0.18	0.36	0.02	0.93	-0.05	0.82	0.23	0.26
U/S-1	60	0.03	0.89	-0.07	0.72	0.04	0.86	0.20	0.32	-0.19	0.36	-0.12	0.57	-0.06	0.77	0.16	0.44	-0.08	0.68	-0.14	0.48	0.30	0.13
U/S-1	120	-0.03	0.90	-0.15	0.45	0.10	0.62	0.12	0.55	-0.22	0.26	-0.15	0.45	-0.01	0.95	0.15	0.45	-0.10	0.61	-0.08	0.70	0.35	0.08
U/S-1	240	-0.02	0.93	-0.06	0.76	0.03	0.87	0.17	0.41	-0.26	0.19	-0.12	0.57	0.02	0.92	0.03	0.88	-0.13	0.54	0.07	0.72	0.49	0.01
U/S-1	480	-0.09	0.65	-0.31	0.13	0.00	1.00	0.07	0.73	-0.13	0.53	-0.23	0.26	-0.14	0.51	0.01	0.96	-0.18	0.37	-0.23	0.27	0.26	0.19
U/S-1	960	0.12	0.57	-0.23	0.24	0.10	0.61	0.14	0.50	-0.26	0.19	-0.31	0.11	0.00	1.00	0.13	0.52	-0.06	0.76	-0.03	0.87	0.46	0.02
U/S-2	30	-0.05	0.81	-0.11	0.60	0.00	1.00	0.36	0.06	-0.43	0.03	-0.30	0.13	0.08	0.69	0.08	0.69	-0.09	0.67	0.04	0.83	0.13	0.53
U/S-2	60	-0.06	0.79	-0.13	0.51	-0.01	0.95	0.30	0.13	-0.45	0.02	-0.33	0.09	0.15	0.47	0.07	0.71	-0.09	0.66	0.01	0.97	0.11	0.57
U/S-2	120	-0.07	0.74	-0.18	0.38	-0.05	0.80	0.23	0.25	-0.45	0.02	-0.31	0.11	0.14	0.49	0.03	0.90	-0.10	0.62	0.00	1.00	0.10	0.62
U/S-2	240	0.06	0.78	-0.09	0.67	0.07	0.72	0.29	0.15	-0.40	0.04	-0.32	0.11	0.26	0.20	0.09	0.67	-0.12	0.57	0.06	0.78	0.25	0.21
U/S-2	480	0.03	0.90	-0.13	0.53	0.08	0.69	0.31	0.12	-0.33	0.09	-0.26	0.19	0.24	0.23	0.12	0.56	-0.12	0.54	0.04	0.85	0.22	0.28
U/S-2	960	0.04	0.84	-0.08	0.70	0.13	0.52	0.31	0.12	-0.33	0.09	-0.25	0.20	0.25	0.20	0.13	0.52	-0.08	0.69	0.03	0.87	0.13	0.52
U/S-3	30	-0.14	0.49	-0.20	0.32	-0.19	0.34	-0.04	0.84	-0.25	0.20	-0.26	0.20	-0.15	0.45	-0.03	0.87	0.02	0.93	0.09	0.66	0.4	0.04
U/S-3	60	-0.07	0.73	-0.29	0.14	-0.12	0.56	-0.02	0.93	-0.23	0.25	-0.21	0.29	-0.10	0.62	0.01	0.94	0.02	0.91	0.04	0.83	0.4	0.04
U/S-3	120	-0.04	0.83	-0.32	0.11	-0.07	0.74	-0.04	0.86	-0.15	0.47	-0.19	0.36	-0.05	0.81	0.03	0.88	-0.03	0.87	-0.05	0.82	0.41	0.03
U/S-3	240	-0.03	0.9	-0.33	0.10	-0.02	0.90	0.02	0.94	-0.17	0.39	-0.21	0.29	0.02	0.92	0.04	0.85	-0.03	0.90	-0.03	0.90	0.41	0.03
U/S-3	480	-0.02	0.92	-0.37	0.06	-0.02	0.92	0.04	0.85	-0.17	0.39	-0.23	0.25	0.00	1.00	0.07	0.75	0.01	0.95	-0.01	0.97	0.37	0.06
U/S-3	960	-0.02	0.911	-0.38	0.05	-0.01	0.95	-0.02	0.94	-0.23	0.25	-0.25	0.20	-0.07	0.72	0.09	0.67	0.10	0.61	0.03	0.88	0.36	0.07

Appendix X. *Cont.*

Land-scape Context	Buffer Width (m)	DBH		USSt		USSp		GCS		TNPS		TAPS		TPS		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.52	0.006	0.04	0.86	0.00	1.00	-0.2	0.32	-0.62	0.001	-0.06	0.77	-0.58	0.002	-0.33	0.10	0.33	0.10	-0.56	0.002
Local	60	0.6	0.001	0.06	0.76	-0.07	0.73	-0.26	0.19	-0.62	0.001	-0.12	0.56	-0.59	0.001	-0.25	0.22	0.25	0.22	-0.58	0.002
Local	120	0.45	0.02	0.09	0.67	-0.04	0.86	-0.20	0.33	-0.63	0.001	0.02	0.93	-0.59	0.001	-0.39	0.05	0.39	0.05	-0.62	0.001
Local	240	0.38	0.05	0.06	0.75	-0.02	0.91	-0.17	0.40	-0.68	0.001	-0.05	0.82	-0.65	0.001	-0.36	0.06	0.36	0.06	-0.65	0.001
Local	480	0.27	0.18	0.12	0.54	0.08	0.71	-0.04	0.85	-0.65	0.001	-0.06	0.77	-0.61	0.001	-0.34	0.08	0.34	0.08	-0.64	0.001
Local	960	0.13	0.51	0.22	0.27	0.20	0.31	0.04	0.85	-0.60	0.001	-0.01	0.97	-0.55	0.003	-0.36	0.07	0.36	0.07	-0.61	0.001
U/S-1	30	0.25	0.20	-0.15	0.45	0.06	0.78	-0.03	0.90	-0.61	0.001	0.05	0.81	-0.61	0.001	-0.36	0.06	0.36	0.06	-0.54	0.004
U/S-1	60	0.18	0.38	-0.06	0.76	0.14	0.50	-0.16	0.42	-0.53	0.004	0.27	0.17	-0.49	0.01	-0.56	0.002	0.56	0.002	-0.49	0.01
U/S-1	120	0.14	0.47	-0.02	0.93	0.22	0.27	-0.10	0.62	-0.46	0.02	0.34	0.08	-0.41	0.04	-0.6	0.001	0.6	0.001	-0.45	0.02
U/S-1	240	0.33	0.10	0.01	0.98	0.24	0.23	-0.05	0.81	-0.48	0.01	0.30	0.13	-0.42	0.03	-0.53	0.004	0.53	0.004	-0.44	0.02
U/S-1	480	0.24	0.23	-0.16	0.44	0.10	0.62	-0.19	0.35	-0.59	0.002	0.14	0.48	-0.53	0.006	-0.52	0.006	0.52	0.006	-0.63	0.001
U/S-1	960	0.17	0.39	-0.12	0.57	0.15	0.45	-0.15	0.46	-0.61	0.001	0.19	0.35	-0.55	0.003	-0.58	0.002	0.58	0.002	-0.63	<0.001
U/S-2	30	-0.02	0.92	-0.16	0.42	0.14	0.47	-0.04	0.83	-0.37	0.06	0.13	0.51	-0.34	0.08	-0.36	0.07	0.363	0.07	-0.38	0.05
U/S-2	60	-0.07	0.74	-0.23	0.24	0.12	0.55	0.00	0.94	-0.33	0.1	0.18	0.36	-0.31	0.12	-0.38	0.05	0.38	0.05	-0.32	0.11
U/S-2	120	-0.04	0.83	-0.27	0.18	0.08	0.68	-0.07	0.73	-0.38	0.05	0.14	0.48	-0.37	0.06	-0.38	0.05	0.38	0.05	-0.36	0.07
U/S-2	240	0.01	0.97	-0.23	0.24	0.07	0.74	-0.07	0.73	-0.45	0.02	0.20	0.31	-0.40	0.04	-0.49	0.009	0.49	0.009	-0.48	0.01
U/S-2	480	0.06	0.75	-0.26	0.20	0.02	0.93	-0.11	0.57	-0.54	0.004	0.12	0.57	-0.49	0.009	-0.48	0.01	0.48	0.01	-0.58	0.002
U/S-2	960	0.11	0.60	-0.28	0.16	-0.02	0.94	-0.14	0.48	-0.53	0.005	0.01	0.94	-0.50	0.008	-0.39	0.04	0.39	0.04	-0.56	0.003
U/S-3	30	-0.12	0.55	-0.12	0.54	0.24	0.23	0.03	0.88	-0.27	0.17	0.22	0.28	-0.24	0.23	-0.33	0.1	0.33	0.1	-0.23	0.25
U/S-3	60	-0.07	0.73	-0.28	0.15	0.08	0.69	-0.12	0.56	-0.42	0.03	0.20	0.31	-0.39	0.04	-0.43	0.02	0.43	0.02	-0.39	0.04
U/S-3	120	-0.02	0.93	-0.29	0.14	0.02	0.90	-0.16	0.42	-0.46	0.02	0.21	0.29	-0.42	0.03	-0.49	0.009	0.49	0.009	-0.45	0.02
U/S-3	240	0.04	0.85	-0.29	0.14	0.03	0.90	-0.17	0.39	-0.47	0.01	0.19	0.35	-0.42	0.03	-0.48	0.01	0.48	0.01	-0.48	0.01
U/S-3	480	-0.09	0.66	-0.30	0.13	0.00	1.00	-0.21	0.30	-0.50	0.008	0.14	0.49	-0.45	0.02	-0.46	0.02	0.46	0.02	-0.51	0.006
U/S-3	960	0.15	0.44	-0.28	0.15	0.00	1.00	-0.23	0.25	-0.49	0.009	0.05	0.80	-0.46	0.02	-0.38	0.05	0.38	0.05	-0.51	0.006

Appendix XI. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of all forest land covers within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray (p<0.01). Community parameter descriptions are provided within the report text.

Landscape Context	Buffer Width (m)	TASR		HQI		MSR		RAIU		RATU		MBTI		MCPUE		FSR		FIBI		RAIF		FCPUE	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	**30**	**-0.34**	**0.08**	**0.06**	**0.77**	**-0.20**	**0.31**	**-0.44**	**0.02**	**0.32**	**0.11**	**0.49**	**0.01**	**-0.19**	**0.34**	**-0.26**	**0.19**	**-0.16**	**0.43**	**-0.13**	**0.53**	**-0.35**	**0.08**
Local	**60**	**-0.38**	**0.05**	**-0.01**	**0.96**	**-0.28**	**0.15**	**-0.48**	**0.01**	**0.25**	**0.21**	**0.39**	**0.05**	**-0.22**	**0.26**	**-0.24**	**0.24**	**-0.10**	**0.60**	**-0.07**	**0.75**	**-0.47**	**0.01**
Local	**120**	**-0.59**	**0.001**	**0.03**	**0.89**	**-0.27**	**0.17**	**-0.41**	**0.04**	**0.25**	**0.20**	**0.43**	**0.03**	**-0.21**	**0.31**	**-0.36**	**0.06**	**-0.18**	**0.38**	**-0.16**	**0.42**	**-0.47**	**0.01**
Local	**240**	**-0.56**	**0.003**	**0.06**	**0.78**	**-0.24**	**0.24**	**-0.29**	**0.14**	**0.14**	**0.47**	**0.30**	**0.13**	**-0.14**	**0.50**	**-0.37**	**0.06**	**-0.17**	**0.41**	**-0.15**	**0.46**	**-0.43**	**0.03**
Local	**480**	**-0.50**	**0.008**	**0.08**	**0.70**	**-0.17**	**0.39**	**-0.24**	**0.23**	**0.11**	**0.59**	**0.29**	**0.15**	**-0.08**	**0.71**	**-0.33**	**0.09**	**-0.14**	**0.50**	**-0.14**	**0.48**	**-0.38**	**0.05**
Local	**960**	**-0.48**	**0.01**	**0.14**	**0.48**	**-0.12**	**0.56**	**-0.23**	**0.25**	**0.11**	**0.59**	**0.35**	**0.08**	**-0.07**	**0.73**	**-0.33**	**0.09**	**-0.14**	**0.49**	**-0.08**	**0.70**	**-0.34**	**0.08**
U/S-1	**30**	**-0.32**	**0.10**	**-0.11**	**0.59**	**0.18**	**0.38**	**-0.39**	**0.04**	**0.25**	**0.22**	**0.23**	**0.26**	**0.10**	**0.62**	**-0.01**	**0.97**	**0.01**	**0.95**	**0.02**	**0.90**	**-0.32**	**0.11**
U/S-1	**60**	**-0.34**	**0.09**	**-0.01**	**0.63**	**0.16**	**0.43**	**-0.36**	**0.06**	**0.26**	**0.20**	**0.23**	**0.26**	**0.11**	**0.59**	**-0.01**	**0.97**	**0.03**	**0.90**	**0.00**	**1.00**	**-0.37**	**0.06**
U/S-1	**120**	**-0.22**	**0.26**	**0.04**	**0.84**	**0.14**	**0.49**	**-0.40**	**0.04**	**0.41**	**0.04**	**0.37**	**0.06**	**0.04**	**0.85**	**0.11**	**0.59**	**0.14**	**0.49**	**-0.16**	**0.42**	**-0.34**	**0.09**
U/S-1	**240**	**-0.29**	**0.14**	**-0.11**	**0.58**	**0.08**	**0.71**	**-0.36**	**0.07**	**0.28**	**0.16**	**0.22**	**0.28**	**0.08**	**0.69**	**0.00**	**1.00**	**0.07**	**0.72**	**-0.08**	**0.69**	**-0.47**	**0.01**
U/S-1	**480**	**-0.35**	**0.08**	**0.00**	**1.00**	**0.00**	**1.00**	**-0.33**	**0.09**	**0.30**	**0.14**	**0.36**	**0.06**	**0.06**	**0.77**	**-0.12**	**0.55**	**-0.01**	**0.97**	**-0.06**	**0.78**	**-0.46**	**0.02**
U/S-1	**960**	**-0.32**	**0.10**	**0.06**	**0.79**	**-0.07**	**0.74**	**-0.36**	**0.06**	**0.21**	**0.29**	**0.39**	**0.05**	**0.06**	**0.79**	**-0.15**	**0.46**	**0.03**	**0.89**	**0.00**	**1.00**	**-0.43**	**0.03**
U/S-2	**30**	**-0.17**	**0.40**	**-0.17**	**0.41**	**0.33**	**0.10**	**-0.35**	**0.07**	**0.42**	**0.03**	**0.32**	**0.10**	**0.10**	**0.61**	**0.10**	**0.63**	**-0.11**	**0.59**	**-0.10**	**0.64**	**-0.19**	**0.34**
U/S-2	**60**	**-0.17**	**0.40**	**-0.17**	**0.40**	**0.32**	**0.11**	**-0.35**	**0.08**	**0.41**	**0.03**	**0.32**	**0.11**	**0.10**	**0.61**	**0.09**	**0.67**	**-0.10**	**0.62**	**-0.09**	**0.66**	**-0.17**	**0.41**
U/S-2	**120**	**-0.21**	**0.30**	**-0.15**	**0.47**	**0.31**	**0.11**	**-0.32**	**0.10**	**0.46**	**0.02**	**0.32**	**0.10**	**0.10**	**0.61**	**0.09**	**0.65**	**-0.14**	**0.49**	**-0.09**	**0.64**	**-0.15**	**0.46**
U/S-2	**240**	**-0.30**	**0.13**	**-0.21**	**0.31**	**0.14**	**0.49**	**-0.44**	**0.02**	**0.50**	**0.008**	**0.41**	**0.04**	**-0.03**	**0.90**	**-0.01**	**0.98**	**-0.12**	**0.55**	**-0.19**	**0.34**	**-0.32**	**0.11**
U/S-2	**480**	**-0.31**	**0.12**	**-0.17**	**0.39**	**0.07**	**0.74**	**-0.46**	**0.02**	**0.47**	**0.01**	**0.38**	**0.05**	**-0.06**	**0.76**	**-0.04**	**0.83**	**-0.08**	**0.69**	**-0.22**	**0.27**	**-0.38**	**0.05**
U/S-2	**960**	**-0.30**	**0.13**	**-0.16**	**0.44**	**0.03**	**0.87**	**-0.49**	**0.01**	**0.44**	**0.02**	**0.40**	**0.04**	**-0.11**	**0.60**	**-0.06**	**0.77**	**-0.05**	**0.79**	**-0.22**	**0.27**	**-0.32**	**0.11**
U/S-3	**30**	**-0.06**	**0.78**	**-0.05**	**0.80**	**0.48**	**-0.16**	**0.44**	**0.44**	**0.28**	**0.15**	**0.25**	**0.21**	**0.24**	**0.24**	**0.23**	**0.25**	**-0.11**	**0.60**	**0.00**	**1.00**	**-0.32**	**0.10**
U/S-3	**60**	**-0.09**	**0.67**	**-0.06**	**0.79**	**0.46**	**-0.15**	**0.44**	**0.44**	**0.27**	**0.17**	**0.21**	**0.28**	**0.25**	**0.22**	**0.19**	**0.33**	**-0.14**	**0.48**	**0.01**	**0.98**	**-0.33**	**0.10**
U/S-3	**120**	**-0.08**	**0.69**	**-0.06**	**0.78**	**0.47**	**-0.23**	**0.26**	**0.26**	**0.29**	**0.14**	**0.24**	**0.22**	**0.28**	**0.15**	**0.21**	**0.29**	**-0.04**	**0.83**	**0.10**	**0.61**	**-0.31**	**0.12**
U/S-3	**240**	**-0.23**	**0.26**	**-0.04**	**0.83**	**0.36**	**-0.27**	**0.18**	**0.18**	**0.27**	**0.17**	**0.28**	**0.16**	**0.15**	**0.47**	**0.13**	**0.54**	**-0.13**	**0.51**	**0.01**	**0.95**	**-0.43**	**0.03**
U/S-3	**480**	**-0.29**	**0.14**	**0.00**	**1.00**	**0.25**	**-0.34**	**0.08**	**0.08**	**0.35**	**0.08**	**0.40**	**0.04**	**0.08**	**0.70**	**0.04**	**0.85**	**-0.19**	**0.33**	**-0.06**	**0.79**	**-0.45**	**0.02**
U/S-3	**960**	**-0.28**	**0.15**	**0.10**	**0.64**	**0.21**	**-0.32**	**0.11**	**0.11**	**0.31**	**0.11**	**0.40**	**0.04**	**0.09**	**0.64**	**0.00**	**1.00**	**-0.21**	**0.30**	**-0.06**	**0.78**	**-0.44**	**0.02**

Appendix XI. *Cont.*

Land-scape Context	Buffer Width (m)	BNSR		INBI		EPT		RAIB		BSR		HSR		#Zone		CTV		BA		NTS	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.29	0.14	-0.18	0.38	-0.18	0.38	-0.15	0.45	0.27	0.29	0.10	0.69	0.38	0.05	0.01	0.95	0.10	0.63	0.04	0.85
Local	60	-0.33	0.09	-0.16	0.42	-0.22	0.26	-0.08	0.69	0.29	0.26	0.13	0.62	0.36	0.06	0.08	0.68	-0.06	0.77	0.08	0.68
Local	120	-0.51	0.006	-0.04	0.83	-0.41	0.03	-0.21	0.29	0.32	0.21	0.20	0.42	0.45	0.02	0.03	0.90	0.03	0.88	-0.06	0.78
Local	240	-0.50	0.009	-0.07	0.73	-0.39	0.05	-0.19	0.34	0.35	0.17	0.25	0.32	0.51	0.007	0.07	0.74	0.07	0.72	-0.04	0.84
Local	480	-0.46	0.02	-0.10	0.63	-0.36	0.07	-0.24	0.23	0.38	0.13	0.24	0.34	0.43	0.03	0.03	0.89	0.16	0.43	-0.03	0.88
Local	960	-0.45	0.02	-0.10	0.62	-0.37	0.06	-0.29	0.14	0.42	0.09	0.21	0.41	0.31	0.11	-0.01	0.98	0.23	0.26	0.01	0.96
U/S-1	30	-0.39	0.04	-0.12	0.54	-0.24	0.22	-0.01	0.95	0.32	0.21	0.30	0.32	0.28	0.15	0.02	0.93	0.10	0.64	0.07	0.74
U/S-1	60	-0.40	0.04	-0.14	0.47	-0.25	0.21	0.00	1.00	0.27	0.29	0.27	0.27	0.32	0.10	0.01	0.96	0.09	0.64	0.07	0.74
U/S-1	120	-0.34	0.08	-0.20	0.31	-0.16	0.42	0.08	0.71	0.11	0.69	0.15	0.11	0.26	0.20	-0.11	0.60	0.18	0.36	0.20	0.31
U/S-1	240	-0.36	0.06	-0.22	0.27	-0.17	0.39	0.04	0.85	0.05	0.86	0.19	0.05	0.39	0.04	-0.04	0.83	0.02	0.93	0.10	0.64
U/S-1	480	-0.37	0.06	-0.11	0.59	-0.22	0.28	-0.15	0.45	0.21	0.42	0.06	0.21	0.33	0.09	0.01	0.95	0.07	0.72	0.16	0.44
U/S-1	960	-0.35	0.08	-0.15	0.45	-0.22	0.27	-0.21	0.30	0.19	0.47	0.08	0.19	0.17	0.39	-0.04	0.83	0.15	0.44	0.25	0.20
U/S-2	30	-0.25	0.20	0.05	0.80	-0.16	0.42	-0.05	0.81	0.16	0.54	-0.07	0.78	-0.02	0.92	-0.07	0.74	0.11	0.60	0.12	0.55
U/S-2	60	-0.24	0.22	0.05	0.81	-0.15	0.46	-0.03	0.90	0.08	0.77	-0.10	0.69	-0.02	0.91	-0.08	0.69	0.13	0.51	0.16	0.43
U/S-2	120	-0.29	0.15	0.10	0.61	-0.19	0.35	-0.06	0.77	0.04	0.89	-0.10	0.69	0.00	1.00	-0.07	0.74	0.15	0.46	0.18	0.37
U/S-2	240	-0.34	0.08	0.05	0.80	-0.23	0.26	-0.11	0.59	0.02	0.95	-0.12	0.63	0.06	0.75	-0.10	0.61	0.11	0.58	0.22	0.28
U/S-2	480	-0.34	0.08	-0.03	0.87	-0.22	0.27	-0.13	0.52	0.08	0.75	-0.01	0.98	0.13	0.54	-0.08	0.68	0.12	0.56	0.17	0.40
U/S-2	960	-0.34	0.08	-0.07	0.74	-0.23	0.26	-0.17	0.39	0.10	0.70	-0.01	0.96	0.09	0.67	-0.04	0.86	0.17	0.41	0.25	0.20
U/S-3	30	-0.15	0.47	0.03	0.87	-0.07	0.72	-0.09	0.66	0.12	0.64	-0.14	0.57	-0.11	0.60	-0.10	0.61	0.12	0.54	0.14	0.50
U/S-3	60	-0.16	0.44	0.06	0.76	-0.09	0.65	-0.07	0.73	0.08	0.76	-0.12	0.63	-0.05	0.81	-0.08	0.71	0.11	0.60	0.12	0.55
U/S-3	120	-0.17	0.39	0.00	1.00	-0.07	0.73	0.04	0.86	-0.07	0.80	-0.11	0.66	0.05	0.80	-0.08	0.69	0.06	0.76	0.12	0.55
U/S-3	240	-0.26	0.19	0.09	0.66	-0.20	0.33	-0.13	0.53	0.06	0.83	-0.19	0.45	0.02	0.94	-0.09	0.65	0.07	0.71	0.14	0.47
U/S-3	480	-0.33	0.09	0.09	0.65	-0.28	0.15	-0.21	0.29	0.09	0.73	-0.07	0.79	0.03	0.88	-0.08	0.68	0.02	0.93	0.13	0.51
U/S-3	960	-0.33	0.09	0.04	0.84	-0.27	0.18	-0.20	0.32	0.08	0.75	-0.08	0.77	0.06	0.77	-0.05	0.79	0.03	0.87	0.22	0.28

Appendix XI. *Cont.*

Land-scape Context	Buffer Width (m)	DBH		USSt		USSp		GCS		TNPS		TAPS		TPS		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.41	0.04	-0.03	0.89	-0.22	0.27	-0.30	0.13	0.38	0.05	0.12	0.56	0.36	0.06	0.10	0.63	-0.10	0.63	0.40	0.04
Local	60	-0.57	0.002	0.02	0.92	-0.10	0.63	-0.01	0.97	0.46	0.02	0.15	0.47	0.42	0.03	0.14	0.48	-0.14	0.48	0.45	0.02
Local	120	-0.39	0.05	-0.13	0.52	-0.13	0.52	0.00	1.00	0.47	0.01	-0.05	0.8	0.42	0.03	0.35	0.08	-0.35	0.08	0.48	0.010
Local	240	-0.44	0.02	-0.13	0.51	-0.08	0.70	0.08	0.69	0.58	0.002	-0.03	0.89	0.54	0.004	0.38	0.05	-0.38	0.05	0.57	0.002
Local	480	-0.36	0.07	-0.14	0.48	-0.11	0.58	0.04	0.84	0.62	0.001	-0.03	0.88	0.58	0.002	0.40	0.04	-0.40	0.04	0.61	0.001
Local	960	-0.24	0.23	-0.15	0.47	-0.14	0.50	0.04	0.83	0.64	<0.001	-0.01	0.96	0.59	0.001	0.40	0.04	-0.40	0.04	0.64	<0.001
U/S-1	30	-0.23	0.26	0.14	0.50	-0.01	0.95	-0.03	0.88	0.44	0.02	0.08	0.68	0.43	0.02	0.13	0.52	-0.13	0.52	0.36	0.07
U/S-1	60	-0.25	0.21	0.13	0.01	-0.02	0.94	0.00	1	0.46	0.02	0.01	0.98	0.45	0.02	0.23	0.26	-0.23	0.26	0.39	0.05
U/S-1	120	-0.28	0.16	0.22	0.27	0.00	1.00	0.01	0.963	0.33	0.09	-0.16	0.43	0.31	0.12	0.28	0.16	-0.28	0.16	0.29	0.14
U/S-1	240	-0.34	0.09	0.12	0.54	-0.05	0.80	-0.02	0.91	0.50	0.008	-0.16	0.44	0.46	0.02	0.4	0.04	-0.40	0.04	0.45	0.02
U/S-1	480	-0.24	0.24	0.19	0.34	-0.01	0.96	0.04	0.85	0.61	0.001	-0.07	0.72	0.58	0.002	0.42	0.03	-0.42	0.03	0.60	0.001
U/S-1	960	-0.26	0.20	0.10	0.63	-0.07	0.74	-0.02	0.91	0.61	0.001	-0.09	0.64	0.56	0.003	0.47	0.01	-0.47	0.01	0.65	<0.001
U/S-2	30	0.03	0.90	0.25	0.20	0.02	0.94	-0.09	0.66	0.20	0.32	0.01	0.98	0.20	0.33	0.05	0.79	-0.05	0.79	0.20	0.33
U/S-2	60	0.03	0.89	0.26	0.20	0.02	0.92	-0.10	0.61	0.18	0.37	-0.04	0.85	0.17	0.40	0.08	0.69	-0.08	0.69	0.17	0.39
U/S-2	120	0.06	0.78	0.33	0.09	0.10	0.62	-0.06	0.78	0.21	0.30	-0.03	0.87	0.21	0.30	0.11	0.57	-0.11	0.57	0.21	0.31
U/S-2	240	0.03	0.87	0.28	0.16	0.01	0.98	-0.14	0.49	0.29	0.15	-0.15	0.46	0.25	0.20	0.29	0.15	-0.29	0.15	0.33	0.09
U/S-2	480	-0.04	0.84	0.21	0.29	-0.06	0.78	-0.14	0.49	0.41	0.03	-0.15	0.46	0.37	0.06	0.38	0.05	-0.38	0.05	0.46	0.02
U/S-2	960	-0.04	0.84	0.25	0.21	-0.02	0.92	-0.11	0.59	0.46	0.02	-0.08	0.70	0.43	0.03	0.36	0.06	-0.36	0.06	0.52	0.006
U/S-3	30	0.11	0.57	0.29	0.14	0.02	0.93	-0.12	0.56	0.17	0.40	0.01	0.96	0.15	0.46	0.05	0.82	-0.05	0.82	0.18	0.36
U/S-3	60	0.10	0.63	0.32	0.11	0.06	0.77	-0.07	0.74	0.22	0.27	0.00	1.00	0.20	0.31	0.10	0.62	-0.10	0.62	0.23	0.24
U/S-3	120	0.02	0.91	0.33	0.10	0.07	0.71	-0.12	0.56	0.22	0.27	-0.07	0.74	0.20	0.33	0.15	0.47	-0.15	0.47	0.23	0.24
U/S-3	240	0.10	0.63	0.34	0.08	0.07	0.73	-0.11	0.58	0.30	0.13	-0.06	0.78	0.27	0.18	0.23	0.25	-0.23	0.25	0.35	0.08
U/S-3	480	0.05	0.79	0.39	0.04	0.09	0.66	-0.08	0.68	0.38	0.05	0.00	1.00	0.35	0.07	0.24	0.23	-0.24	0.23	0.43	0.03
U/S-3	960	-0.02	0.94	0.42	0.03	0.12	0.56	-0.05	0.82	0.48	0.01	0.03	0.03	0.44	0.02	0.29	0.14	-0.29	0.14	0.55	0.003

Appendix XII. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of all wetland land covers within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray (p<0.01). Community parameter descriptions are provided within the report text.

Land-scape Context	Buffer Width (m)	TASR		HQI		MSR		RAIU		RATU		MBTI		MCPUE		FSR		FIBI		RAIF		FCPUE	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.28	0.17	0.25	0.22	0.00	1.00	0.39	0.05	-0.21	0.30	-0.21	0.29	0.22	0.28	0.03	0.89	0.22	0.27	0.14	0.48	0.06	0.76
Local	60	0.17	0.41	0.06	0.76	0.07	0.74	0.22	0.26	-0.19	0.35	-0.11	0.58	0.27	0.18	0.04	0.86	0.12	0.54	-0.03	0.88	0.02	0.94
Local	120	0.09	0.65	0.14	0.49	0.11	0.59	0.20	0.31	-0.22	0.27	-0.08	0.71	0.24	0.24	0.05	0.81	0.14	0.49	-0.03	0.90	0.03	0.88
Local	240	0.06	0.78	0.13	0.51	0.06	0.78	0.17	0.41	-0.16	0.41	0.00	1.00	0.21	0.30	0.01	0.96	0.11	0.59	-0.05	0.82	-0.02	0.91
Local	480	0.05	0.80	0.13	0.52	0.02	0.92	0.07	0.72	-0.05	0.81	0.10	0.63	0.23	0.25	-0.02	0.94	0.06	0.77	-0.12	0.56	-0.11	0.57
Local	960	-0.07	0.72	0.07	0.74	-0.03	0.90	0.01	0.98	0.10	0.61	0.32	0.11	0.22	0.28	-0.21	0.30	-0.16	0.44	-0.14	0.49	-0.15	0.45
U/S-1	30	0.35	0.07	0.27	0.17	-0.20	0.33	0.28	0.17	-0.42	0.03	-0.26	0.19	0.12	0.56	-0.09	0.65	0.13	0.50	0.10	0.63	0.18	0.38
U/S-1	60	0.42	0.03	0.24	0.23	-0.21	0.31	0.33	0.09	-0.46	0.02	-0.40	0.04	0.11	0.57	-0.08	0.71	0.17	0.40	0.20	0.31	0.13	0.52
U/S-1	120	0.37	0.06	0.21	0.29	-0.22	0.27	0.32	0.10	-0.49	0.01	-0.41	0.03	0.07	0.74	-0.09	0.66	0.16	0.42	0.18	0.37	0.12	0.57
U/S-1	240	0.45	0.02	0.28	0.15	-0.16	0.42	0.38	0.05	-0.46	0.02	-0.44	0.02	0.15	0.47	-0.04	0.84	0.16	0.42	0.19	0.35	0.17	0.39
U/S-1	480	0.47	0.02	0.35	0.08	-0.19	0.34	0.31	0.12	-0.48	0.01	-0.43	0.03	0.13	0.52	-0.05	0.82	0.25	0.20	0.24	0.23	0.25	0.21
U/S-1	960	0.39	0.05	0.46	0.02	-0.17	0.40	0.27	0.17	-0.43	0.03	-0.30	0.14	0.15	0.46	-0.07	0.73	0.25	0.21	0.25	0.22	0.15	0.46
U/S-2	30	0.16	0.42	0.18	0.36	-0.43	0.03	0.06	0.77	-0.23	0.24	-0.17	0.39	-0.17	0.39	-0.36	0.07	0.09	0.67	0.08	0.70	0.35	0.07
U/S-2	60	0.16	0.42	0.19	0.35	-0.44	0.02	0.06	0.78	-0.23	0.26	-0.16	0.42	-0.17	0.39	-0.36	0.06	0.08	0.68	0.08	0.69	0.35	0.08
U/S-2	120	0.16	0.43	0.17	0.40	-0.44	0.02	0.05	0.80	-0.26	0.20	-0.18	0.37	-0.19	0.36	-0.38	0.05	0.08	0.69	0.10	0.61	0.32	0.10
U/S-2	240	0.25	0.21	0.24	0.23	-0.39	0.04	0.11	0.59	-0.31	0.11	-0.21	0.30	-0.08	0.68	-0.37	0.06	0.11	0.58	0.15	0.44	0.35	0.08
U/S-2	480	0.26	0.19	0.25	0.22	-0.32	0.10	0.12	0.55	-0.21	0.31	-0.15	0.46	-0.09	0.66	-0.32	0.10	0.07	0.72	0.19	0.34	0.34	0.08
U/S-2	960	0.27	0.18	0.27	0.17	-0.38	0.05	0.04	0.84	-0.16	0.41	-0.11	0.60	-0.13	0.50	-0.35	0.08	0.10	0.63	0.18	0.38	0.26	0.20
U/S-3	30	0.19	0.36	0.08	0.69	-0.45	0.02	0.27	0.17	-0.25	0.21	-0.24	0.23	-0.10	0.60	-0.22	0.26	0.10	0.64	-0.17	0.41	0.07	0.75
U/S-3	60	0.15	0.44	0.14	0.50	-0.48	0.01	0.25	0.20	-0.29	0.15	-0.28	0.16	-0.11	0.60	-0.23	0.24	0.12	0.57	-0.12	0.56	0.05	0.79
U/S-3	120	0.14	0.50	0.16	0.42	-0.42	0.03	0.31	0.12	-0.29	0.15	-0.28	0.16	-0.11	0.58	-0.19	0.34	0.08	0.70	-0.12	0.55	0.01	0.95
U/S-3	240	0.20	0.31	0.20	0.32	-0.42	0.03	0.28	0.16	-0.22	0.26	-0.22	0.28	-0.07	0.74	-0.18	0.38	0.12	0.55	-0.09	0.66	0.05	0.81
U/S-3	480	0.25	0.22	0.27	0.17	-0.36	0.07	0.30	0.13	-0.21	0.30	-0.21	0.30	-0.03	0.89	-0.16	0.43	0.14	0.49	-0.03	0.90	0.06	0.78
U/S-3	960	0.25	0.21	0.29	0.14	-0.37	0.06	0.28	0.16	-0.15	0.45	-0.16	0.42	-0.07	0.74	-0.19	0.36	0.07	0.72	-0.08	0.68	-0.03	0.90

Appendix XII. *Cont.*

Land-scape Context	Buffer Width (m)	BNSR		INBI		EPT		RAIB		BSR		HSR		#Zone		CTV		BA		NTS	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.30	0.13	0.06	0.77	0.18	0.37	-0.06	0.75	0.26	0.32	0.30	0.23	-0.13	0.53	-0.10	0.61	-0.23	0.25	-0.27	0.17
Local	60	0.15	0.45	-0.06	0.76	0.21	0.29	-0.12	0.56	0.27	0.30	0.29	0.25	0.08	0.70	0.12	0.55	-0.11	0.58	-0.09	0.66
Local	120	0.04	0.83	-0.05	0.81	0.11	0.60	-0.17	0.41	0.35	0.16	0.27	0.28	0.05	0.82	0.05	0.81	-0.04	0.84	-0.04	0.85
Local	240	0.01	0.98	-0.05	0.81	0.08	0.70	-0.25	0.20	0.36	0.15	0.29	0.24	0.09	0.65	0.09	0.65	-0.05	0.79	-0.07	0.73
Local	480	0.00	1.00	-0.12	0.54	0.09	0.67	-0.21	0.30	0.29	0.27	0.33	0.18	0.14	0.48	0.02	0.91	0.03	0.89	0.01	0.95
Local	960	-0.08	0.70	-0.10	0.61	-0.02	0.91	-0.39	0.04	0.37	0.14	0.09	0.71	0.14	0.48	0.08	0.68	0.07	0.75	-0.08	0.68
U/S-1	30	0.39	0.05	0.03	0.87	0.31	0.12	0.19	0.35	0.10	0.71	0.13	0.61	-0.09	0.67	0.06	0.76	-0.09	0.67	0.14	0.50
U/S-1	60	0.46	0.02	0.02	0.91	0.33	0.10	0.27	0.18	0.00	1.00	0.19	0.45	-0.09	0.66	0.02	0.92	-0.23	0.24	0.02	0.92
U/S-1	120	0.42	0.03	0.05	0.82	0.28	0.15	0.23	0.26	0.03	0.90	0.23	0.36	-0.10	0.63	0.05	0.82	-0.24	0.24	0.02	0.92
U/S-1	240	0.49	0.01	0.00	1.00	0.36	0.07	0.28	0.17	0.07	0.78	0.27	0.28	-0.07	0.75	0.05	0.80	-0.21	0.30	-0.02	0.94
U/S-1	480	0.52	0.005	0.02	0.91	0.38	0.05	0.30	0.14	0.15	0.56	0.28	0.26	-0.11	0.60	-0.05	0.80	-0.20	0.31	-0.02	0.91
U/S-1	960	0.45	0.02	0.01	0.95	0.34	0.08	0.33	0.10	0.26	0.31	0.11	0.67	-0.07	0.72	-0.10	0.61	-0.14	0.47	0.05	0.82
U/S-2	30	0.27	0.18	0.12	0.54	0.12	0.54	0.03	0.87	0.12	0.64	0.21	0.40	-0.15	0.47	-0.10	0.62	-0.10	0.63	0.06	0.75
U/S-2	60	0.27	0.18	0.13	0.54	0.13	0.53	0.03	0.87	0.12	0.64	0.20	0.42	-0.15	0.47	-0.10	0.63	-0.10	0.61	0.06	0.76
U/S-2	120	0.26	0.19	0.11	0.60	0.12	0.56	0.02	0.92	0.15	0.57	0.20	0.44	-0.12	0.54	-0.07	0.74	-0.13	0.53	0.04	0.83
U/S-2	240	0.33	0.09	0.03	0.88	0.20	0.32	0.05	0.81	0.25	0.34	0.33	0.19	-0.14	0.48	-0.07	0.74	-0.13	0.51	-0.03	0.88
U/S-2	480	0.34	0.08	0.08	0.69	0.17	0.39	0.00	1.00	0.33	0.20	0.22	0.38	-0.19	0.34	-0.10	0.61	-0.12	0.56	-0.02	0.94
U/S-2	960	0.37	0.06	0.08	0.69	0.19	0.34	0.08	0.71	0.39	0.13	0.31	0.21	-0.08	0.71	-0.08	0.70	-0.16	0.42	-0.06	0.77
U/S-3	30	0.30	0.13	0.12	0.54	0.12	0.54	-0.10	0.61	0.28	0.27	0.53	0.02	-0.17	0.41	-0.14	0.49	-0.15	0.47	-0.20	0.32
U/S-3	60	0.27	0.17	0.13	0.52	0.12	0.56	-0.01	0.98	0.12	0.64	0.45	0.06	-0.10	0.62	-0.12	0.56	-0.21	0.30	-0.17	0.39
U/S-3	120	0.25	0.21	0.17	0.41	0.10	0.63	-0.07	0.72	0.22	0.39	0.33	0.19	-0.16	0.43	-0.13	0.53	-0.18	0.37	-0.12	0.57
U/S-3	240	0.28	0.16	0.08	0.69	0.14	0.48	0.01	0.95	0.23	0.38	0.43	0.08	-0.11	0.59	-0.10	0.64	-0.23	0.26	-0.15	0.47
U/S-3	480	0.32	0.11	0.03	0.89	0.19	0.34	0.09	0.66	0.35	0.17	0.42	0.08	-0.06	0.77	-0.08	0.70	-0.23	0.24	-0.15	0.47
U/S-3	960	0.34	0.08	0.04	0.86	0.21	0.29	0.10	0.61	0.45	0.07	0.42	0.08	-0.01	0.96	-0.01	0.95	-0.24	0.23	-0.18	0.38

Appendix XII. *Cont.*

Land-scape Context	Buffer Width (m)	DBH		USSt		USSp		GCS		TNPS		TAPS		TPS		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.01	0.96	-0.21	0.29	-0.04	0.84	0.35	0.08	0.16	0.43	-0.14	0.50	0.13	0.53	0.27	0.17	-0.27	0.17	0.18	0.38
Local	60	-0.13	0.52	0.03	0.88	0.18	0.37	0.29	0.14	0.33	0.09	0.10	0.62	0.33	0.09	0.12	0.56	-0.12	0.56	0.31	0.12
Local	120	-0.12	0.54	0.05	0.82	0.18	0.36	0.27	0.17	0.39	0.04	0.15	0.45	0.39	0.05	0.10	0.62	-0.10	0.62	0.38	0.05
Local	240	-0.15	0.46	0.02	0.94	0.12	0.56	0.21	0.31	0.38	0.05	0.15	0.46	0.37	0.06	0.08	0.68	-0.08	0.68	0.39	0.05
Local	480	-0.15	0.45	0.04	0.84	0.04	0.83	0.12	0.54	0.46	0.02	0.08	0.70	0.44	0.02	0.21	0.29	-0.21	0.29	0.49	0.009
Local	960	-0.05	0.80	-0.07	0.72	-0.13	0.52	-0.06	0.77	0.32	0.10	0.13	0.53	0.32	0.11	0.09	0.65	-0.09	0.65	0.40	0.04
U/S-1	30	0.09	0.66	0.09	0.66	0.11	0.60	0.21	0.29	0.20	0.31	-0.05	0.82	0.19	0.36	0.23	0.25	-0.23	0.25	0.29	0.14
U/S-1	60	0.06	0.78	-0.02	0.93	0.02	0.94	0.21	0.29	0.18	0.37	-0.10	0.63	0.15	0.46	0.27	0.17	-0.27	0.17	0.26	0.20
U/S-1	120	0.05	0.81	-0.03	0.90	0.04	0.83	0.25	0.21	0.20	0.32	-0.08	0.70	0.17	0.40	0.26	0.19	-0.26	0.19	0.26	0.19
U/S-1	240	0.06	0.77	0.02	0.92	0.04	0.86	0.28	0.16	0.23	0.26	-0.05	0.81	0.21	0.30	0.26	0.20	-0.26	0.20	0.28	0.15
U/S-1	480	-0.01	0.96	0.02	0.93	0.02	0.91	0.36	0.07	0.29	0.14	-0.08	0.68	0.27	0.18	0.33	0.09	-0.33	0.09	0.32	0.10
U/S-1	960	0.04	0.84	0.02	0.91	0.02	0.94	0.25	0.22	0.27	0.17	-0.13	0.52	0.23	0.25	0.39	0.04	-0.39	0.04	0.37	0.06
U/S-2	30	-0.05	0.82	-0.09	0.67	0.01	0.95	0.27	0.17	0.13	0.51	-0.08	0.68	0.12	0.56	0.23	0.26	-0.23	0.26	0.17	0.40
U/S-2	60	-0.03	0.87	-0.09	0.65	0.00	1.00	0.25	0.20	0.11	0.58	-0.08	0.68	0.10	0.62	0.22	0.28	-0.22	0.28	0.15	0.45
U/S-2	120	-0.07	0.75	-0.08	0.71	0.01	0.98	0.27	0.18	0.19	0.35	-0.04	0.86	0.17	0.39	0.22	0.28	-0.22	0.28	0.23	0.26
U/S-2	240	-0.05	0.80	-0.14	0.48	-0.08	0.68	0.21	0.29	0.21	0.31	0.00	1.00	0.20	0.32	0.18	0.36	-0.18	0.36	0.23	0.24
U/S-2	480	0.08	0.71	-0.02	0.94	-0.06	0.76	0.22	0.28	0.24	0.23	0.06	0.77	0.24	0.22	0.18	0.36	-0.18	0.36	0.28	0.16
U/S-2	960	-0.02	0.93	-0.10	0.97	-0.06	0.75	0.24	0.23	0.32	0.10	0.02	0.91	0.32	0.11	0.27	0.17	-0.27	0.17	0.36	0.06
U/S-3	30	-0.01	0.96	-0.41	0.03	-0.28	0.16	0.08	0.68	-0.09	0.67	-0.11	0.57	-0.08	0.69	0.09	0.67	-0.09	0.67	-0.07	0.73
U/S-3	60	-0.05	0.82	-0.31	0.11	-0.19	0.35	0.15	0.45	0.01	0.95	-0.14	0.48	0.01	0.95	0.18	0.36	-0.18	0.36	0.04	0.85
U/S-3	120	0.00	1.00	-0.24	0.22	-0.15	0.45	0.17	0.39	0.05	0.82	-0.08	0.68	0.05	0.80	0.16	0.42	-0.16	0.42	0.08	0.69
U/S-3	240	-0.06	0.78	-0.21	0.28	-0.17	0.40	0.14	0.47	0.06	0.79	-0.05	0.82	0.06	0.76	0.12	0.56	-0.12	0.56	0.09	0.67
U/S-3	480	-0.10	0.62	-0.17	0.40	-0.15	0.45	0.18	0.36	0.12	0.57	-0.02	0.90	0.12	0.55	0.14	0.48	-0.14	0.48	0.13	0.51
U/S-3	960	-0.06	0.76	-0.13	0.52	-0.17	0.41	0.19	0.36	0.17	0.40	0.01	0.98	0.18	0.38	0.15	0.46	-0.15	0.46	0.18	0.38

Appendix XIII. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of wetland and forest land covers combined within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray (p<0.01). Community parameter descriptions are provided within the report text.

Land-scape Context	Buffer Width (m)	TASR		HQI		MSR		RAIU		RATU		MBTI		MCPUE		FSR		FIBI		RAIF		FCPUE	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.31	0.12	0.20	0.33	-0.25	0.20	-0.22	0.27	0.28	0.17	0.42	0.30	-0.10	0.62	-0.33	0.10	-0.11	0.58	-0.03	0.88	-0.35	0.08
Local	60	-0.39	0.05	0.04	0.86	-0.26	0.19	-0.33	0.09	0.21	0.29	0.37	0.06	-0.06	0.76	-0.31	0.12	-0.12	0.54	-0.13	0.51	-0.47	0.01
Local	120	-0.54	0.004	0.05	0.80	-0.25	0.21	-0.27	0.18	0.14	0.49	0.34	0.08	-0.07	0.73	-0.37	0.06	-0.13	0.52	-0.17	0.39	-0.40	0.04
Local	240	-0.48	0.01	0.03	0.88	-0.20	0.31	-0.18	0.36	0.06	0.78	0.23	0.25	-0.03	0.90	-0.35	0.08	-0.12	0.54	-0.17	0.39	-0.38	0.05
Local	480	-0.44	0.02	0.10	0.61	-0.09	0.67	-0.15	0.44	0.07	0.71	0.29	0.15	0.02	0.94	-0.28	0.16	-0.10	0.62	-0.11	0.60	-0.34	0.09
Local	960	-0.42	0.03	0.13	0.51	-0.08	0.70	-0.19	0.34	0.13	0.53	0.36	0.06	-0.01	0.98	-0.31	0.12	-0.13	0.54	-0.09	0.65	-0.32	0.10
U/S-1	30	-0.13	0.52	0.01	0.96	0.13	0.52	-0.32	0.10	0.15	0.45	0.18	0.38	0.22	0.28	-0.05	0.79	0.05	0.81	0.08	0.68	-0.25	0.22
U/S-1	60	-0.09	0.66	0.07	0.72	0.07	0.74	-0.20	0.32	0.09	0.67	0.06	0.77	0.20	0.31	-0.08	0.68	0.10	0.61	0.12	0.54	-0.30	0.14
U/S-1	120	0.00	1.00	0.19	0.34	0.05	0.80	-0.21	0.29	0.21	0.31	0.18	0.38	0.10	0.61	0.04	0.83	0.24	0.23	-0.04	0.84	-0.25	0.21
U/S-1	240	0.02	0.92	0.11	0.58	0.02	0.91	-0.16	0.44	0.13	0.51	0.05	0.79	0.13	0.52	0.01	0.97	0.20	0.31	0.01	0.95	-0.39	0.05
U/S-1	480	-0.09	0.67	0.23	0.25	-0.07	0.74	-0.12	0.55	0.10	0.64	0.18	0.37	0.11	0.58	-0.09	0.67	0.16	0.43	0.09	0.65	-0.38	0.05
U/S-1	960	-0.05	0.82	0.26	0.18	-0.09	0.64	-0.19	0.35	0.07	0.73	0.24	0.24	0.11	0.58	-0.09	0.66	0.20	0.31	0.15	0.45	-0.29	0.14
U/S-2	30	-0.05	0.80	-0.05	0.81	0.01	0.97	-0.38	0.05	0.43	0.02	0.31	0.12	-0.05	0.82	-0.13	0.51	-0.07	0.74	-0.19	0.34	-0.06	0.76
U/S-2	60	-0.03	0.90	-0.02	0.94	0.03	0.90	-0.37	0.06	0.47	0.01	0.35	0.08	-0.11	0.58	-0.14	0.49	-0.04	0.85	-0.14	0.50	-0.03	0.89
U/S-2	120	-0.04	0.84	-0.04	0.85	0.00	1.00	-0.30	0.13	0.47	0.01	0.30	0.13	-0.12	0.56	-0.12	0.56	-0.07	0.75	-0.16	0.44	-0.04	0.84
U/S-2	240	-0.07	0.74	-0.03	0.90	-0.11	0.59	-0.35	0.08	0.43	0.03	0.32	0.11	-0.15	0.46	-0.19	0.35	-0.02	0.94	-0.13	0.51	-0.16	0.44
U/S-2	480	-0.03	0.90	0.00	1.00	-0.16	0.44	-0.29	0.14	0.34	0.08	0.24	0.24	-0.15	0.45	-0.17	0.40	0.07	0.74	-0.12	0.57	-0.17	0.39
U/S-2	960	-0.05	0.80	0.01	0.98	-0.14	0.49	-0.31	0.12	0.28	0.15	0.23	0.25	-0.18	0.38	-0.14	0.48	0.09	0.66	-0.08	0.70	-0.10	0.64
U/S-3	30	-0.03	0.88	0.01	0.97	0.21	0.30	-0.09	0.66	0.38	0.05	0.37	0.06	0.18	0.37	-0.05	0.80	-0.24	0.23	-0.18	0.38	-0.37	0.06
U/S-3	60	-0.05	0.79	0.13	0.53	0.15	0.47	-0.07	0.72	0.31	0.12	0.29	0.15	0.19	0.33	-0.09	0.66	-0.22	0.26	-0.11	0.58	-0.40	0.04
U/S-3	120	-0.01	0.97	0.14	0.49	0.10	0.64	-0.07	0.73	0.25	0.21	0.30	0.13	0.18	0.36	-0.06	0.77	-0.09	0.66	-0.02	0.91	-0.37	0.05
U/S-3	240	-0.05	0.81	0.13	0.52	0.04	0.86	-0.10	0.62	0.21	0.31	0.25	0.21	0.10	0.62	-0.07	0.75	-0.08	0.69	-0.08	0.70	-0.47	0.01
U/S-3	480	-0.03	0.90	0.21	0.28	0.02	0.92	-0.09	0.67	0.22	0.28	0.26	0.19	0.08	0.69	-0.06	0.76	-0.07	0.72	-0.05	0.82	-0.43	0.02
U/S-3	960	-0.03	0.88	0.28	0.16	0.03	0.90	-0.06	0.75	0.15	0.46	0.25	0.21	0.14	0.48	-0.09	0.67	-0.08	0.68	-0.03	0.87	-0.38	0.05

Appendix XIII. *Cont.*

Land-scape Context	Buffer Width (m)	BNSR		INBI		EPT		RAIB		BSR		HSR		#Zone		CTV		BA		NTS	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.20	0.31	-0.22	0.26	-0.09	0.67	-0.17	0.41	0.32	0.21	0.08	0.74	0.42	0.03	0.02	0.91	-0.04	0.84	-0.09	0.64
Local	60	-0.33	0.09	-0.15	0.47	-0.19	0.34	-0.23	0.25	0.41	0.10	0.15	0.54	0.45	0.02	0.14	0.49	-0.13	0.52	-0.04	0.86
Local	120	-0.49	0.01	-0.04	0.83	-0.37	0.06	-0.33	0.10	0.38	0.13	0.18	0.47	0.45	0.02	0.02	0.91	-0.02	0.94	-0.08	0.68
Local	240	-0.43	0.03	-0.04	0.86	-0.34	0.08	-0.29	0.14	0.42	0.10	0.30	0.23	0.49	0.01	0.07	0.73	0.09	0.67	-0.03	0.89
Local	480	-0.42	0.03	-0.12	0.56	-0.33	0.10	-0.30	0.13	0.45	0.07	0.24	0.34	0.38	0.05	0.02	0.91	0.16	0.43	-0.05	0.79
Local	960	-0.42	0.03	-0.09	0.65	-0.36	0.07	-0.36	0.07	0.42	0.09	0.21	0.41	0.26	0.20	-0.01	0.97	0.23	0.26	-0.01	0.97
U/S-1	30	-0.19	0.34	-0.13	0.52	-0.07	0.74	0.07	0.73	0.24	0.35	0.29	0.24	0.26	0.19	0.09	0.66	0.16	0.42	0.21	0.29
U/S-1	60	-0.12	0.56	-0.14	0.48	-0.03	0.89	0.14	0.49	0.20	0.44	0.24	0.35	0.31	0.12	0.04	0.86	0.10	0.62	0.17	0.40
U/S-1	120	-0.08	0.71	-0.14	0.49	0.00	1.00	0.14	0.48	0.15	0.57	0.21	0.40	0.18	0.38	-0.13	0.52	0.12	0.55	0.21	0.31
U/S-1	240	-0.03	0.90	-0.22	0.27	0.05	0.82	0.12	0.56	0.11	0.69	0.29	0.25	0.31	0.12	-0.09	0.66	-0.02	0.92	0.09	0.67
U/S-1	480	-0.08	0.70	-0.09	0.67	-0.05	0.83	-0.03	0.87	0.27	0.29	0.09	0.72	0.19	0.34	-0.08	0.70	-0.02	0.94	0.13	0.51
U/S-1	960	-0.05	0.82	-0.14	0.48	-0.03	0.90	-0.07	0.73	0.20	0.43	0.09	0.71	0.08	0.71	-0.15	0.45	0.05	0.79	0.18	0.38
U/S-2	30	-0.09	0.67	0.04	0.85	-0.09	0.65	-0.13	0.53	0.24	0.36	0.29	0.25	-0.04	0.85	-0.14	0.50	0.13	0.51	0.17	0.40
U/S-2	60	-0.03	0.89	0.04	0.86	-0.05	0.80	-0.06	0.75	0.30	0.25	0.17	0.49	0.00	1.00	-0.16	0.42	0.18	0.37	0.23	0.24
U/S-2	120	-0.04	0.85	0.05	0.80	-0.04	0.85	-0.05	0.81	0.21	0.43	0.13	0.62	0.03	0.87	-0.15	0.47	0.16	0.42	0.25	0.21
U/S-2	240	-0.03	0.89	0.07	0.74	-0.05	0.83	-0.09	0.65	0.21	0.42	0.16	0.53	0.06	0.77	-0.15	0.46	0.03	0.87	0.19	0.35
U/S-2	480	0.01	0.94	0.02	0.93	0.00	1.00	-0.07	0.74	0.22	0.40	0.14	0.59	0.07	0.72	-0.12	0.55	-0.03	0.87	0.13	0.54
U/S-2	960	-0.04	0.84	0.03	0.90	-0.08	0.70	-0.09	0.65	0.20	0.44	0.08	0.75	-0.01	0.97	-0.12	0.56	0.02	0.93	0.21	0.29
U/S-3	30	-0.05	0.82	0.11	0.57	-0.10	0.62	-0.21	0.29	0.44	0.08	0.33	0.18	-0.05	0.80	-0.15	0.45	0.05	0.82	0.07	0.74
U/S-3	60	-0.04	0.84	0.15	0.46	-0.09	0.64	-0.07	0.74	0.36	0.16	0.29	0.25	0.08	0.68	-0.06	0.76	-0.07	0.73	0.04	0.83
U/S-3	120	0.02	0.91	0.15	0.44	-0.07	0.73	-0.01	0.97	0.31	0.23	0.29	0.24	0.04	0.86	-0.13	0.54	-0.12	0.54	0.05	0.80
U/S-3	240	-0.01	0.97	0.19	0.35	-0.11	0.59	-0.07	0.72	0.31	0.23	0.23	0.37	0.06	0.75	-0.11	0.60	-0.17	0.41	0.01	0.98
U/S-3	480	0.02	0.94	0.15	0.46	-0.10	0.63	-0.08	0.70	0.24	0.36	0.16	0.53	0.04	0.84	-0.11	0.57	-0.16	0.41	0.02	0.94
U/S-3	960	-0.01	0.96	0.10	0.61	-0.09	0.64	-0.07	0.72	0.22	0.39	0.12	0.63	-0.03	0.90	-0.08	0.69	-0.14	0.48	0.07	0.71

Appendix XIII. *Cont.*

Land-scape Context	Buffer Width (m)	DBH		USSt		USSp		GCS		TNPS		TAPS		TPS		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.53	0.004	-0.13	0.51	-0.17	0.41	0.01	0.95	0.54	0.004	0.09	0.65	0.51	0.007	0.26	0.19	-0.26	0.19	0.53	0.005
Local	60	-0.61	0.001	-0.03	0.89	-0.05	0.80	0.18	0.38	0.60	0.001	0.13	0.51	0.57	0.002	0.25	0.21	-0.25	0.21	0.61	0.001
Local	120	-0.47	0.01	-0.11	0.59	-0.08	0.70	0.16	0.43	0.63	<0.001	0.00	1.00	0.58	0.001	0.38	0.05	-0.38	0.05	0.64	<0.001
Local	240	-0.46	0.02	-0.09	0.67	-0.02	0.91	0.19	0.36	0.66	<0.001	-0.01	0.98	0.62	<0.001	0.41	0.03	-0.41	0.03	0.65	<0.001
Local	480	-0.34	0.08	-0.10	0.61	-0.09	0.66	0.09	0.64	0.65	<0.001	0.04	0.85	0.62	0.001	0.36	0.07	-0.36	0.07	0.64	<0.001
Local	960	-0.22	0.28	-0.14	0.48	-0.15	0.45	0.06	0.76	0.63	<0.001	-0.01	0.98	0.59	0.001	0.38	0.05	-0.38	0.05	0.64	<0.001
U/S-1	30	-0.20	0.33	0.21	0.28	0.02	0.91	-0.02	0.91	0.52	0.005	0.04	0.86	0.51	0.006	0.24	0.23	-0.24	0.23	0.50	0.01
U/S-1	60	-0.21	0.30	0.14	0.49	-0.01	0.94	0.12	0.54	0.57	0.002	-0.16	0.44	0.53	0.005	0.47	0.01	-0.47	0.01	0.55	0.00
U/S-1	120	-0.18	0.36	0.17	0.41	-0.03	0.90	0.19	0.34	0.41	0.04	-0.33	0.09	0.35	0.07	0.52	0.005	-0.52	0.005	0.40	0.04
U/S-1	240	-0.28	0.15	0.07	0.73	-0.12	0.56	0.14	0.50	0.55	0.003	-0.31	0.11	0.49	0.01	0.62	0.001	-0.62	0.001	0.55	0.003
U/S-1	480	-0.13	0.52	0.13	0.53	-0.07	0.73	0.19	0.34	0.60	0.001	-0.22	0.26	0.53	0.005	0.62	0.001	-0.62	0.001	0.64	<0.001
U/S-1	960	-0.18	0.38	0.07	0.72	-0.14	0.50	0.09	0.64	0.59	0.001	-0.21	0.29	0.52	0.006	0.60	0.001	-0.60	0.001	0.65	<0.001
U/S-2	30	0.00	1.00	0.24	0.22	-0.08	0.70	0.03	0.90	0.44	0.02	-0.04	0.85	0.44	0.02	0.29	0.14	-0.29	0.14	0.44	0.02
U/S-2	60	0.06	0.78	0.30	0.12	-0.06	0.75	0.01	0.98	0.39	0.04	-0.09	0.64	0.39	0.05	0.31	0.12	-0.31	0.12	0.36	0.06
U/S-2	120	0.07	0.72	0.35	0.07	0.01	0.97	0.06	0.76	0.42	0.03	-0.11	0.60	0.42	0.03	0.36	0.07	-0.36	0.07	0.40	0.04
U/S-2	240	0.02	0.92	0.26	0.18	-0.06	0.78	0.04	0.86	0.48	0.01	-0.19	0.36	0.45	0.02	0.49	0.01	-0.49	0.01	0.50	0.007
U/S-2	480	-0.01	0.97	0.21	0.30	-0.07	0.72	0.08	0.68	0.52	0.005	-0.22	0.27	0.47	0.01	0.56	0.002	-0.56	0.002	0.57	0.002
U/S-2	960	-0.04	0.86	0.26	0.18	0.00	1.00	0.12	0.56	0.50	0.008	-0.12	0.56	0.46	0.02	0.47	0.01	-0.47	0.01	0.56	0.002
U/S-3	30	0.08	0.68	0.25	0.21	-0.11	0.59	-0.08	0.70	0.32	0.10	0.07	0.74	0.32	0.11	0.10	0.62	-0.10	0.62	0.30	0.14
U/S-3	60	0.00	1.00	0.39	0.04	0.04	0.85	0.08	0.71	0.50	0.009	0.04	0.85	0.49	0.01	0.26	0.19	-0.26	0.19	0.48	0.01
U/S-3	120	0.02	0.91	0.40	0.04	0.05	0.79	0.03	0.88	0.42	0.03	-0.05	0.81	0.40	0.04	0.30	0.12	-0.30	0.12	0.41	0.03
U/S-3	240	0.05	0.79	0.34	0.08	0.02	0.94	0.07	0.72	0.44	0.02	-0.14	0.49	0.40	0.04	0.41	0.04	-0.41	0.04	0.47	0.01
U/S-3	480	0.01	0.98	0.34	0.08	0.01	0.95	0.11	0.60	0.45	0.02	-0.13	0.51	0.40	0.04	0.42	0.03	-0.42	0.03	0.49	0.010
U/S-3	960	-0.02	0.94	0.31	0.11	0.03	0.87	0.13	0.51	0.47	0.01	-0.13	0.68	0.42	0.030	0.40	0.04	-0.40	0.04	0.51	0.006